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PROGRESS IN ARMY EDUCATION

THE Army Education Scheme (Interim Period)*, concerning which a statement by Major-General Cyril Lloyd, director of Army education, appears on p. 262 of this issue, has now become effective. In view of the wide and keen interest in adult education to-day, the developments in compulsory national service, and the concern of everyone that the education of the youth of the country should be interrupted as little as possible, it is to be hoped that this new Scheme will receive close study and careful discussion.

Education of some sort or another is nothing new in the British Army. It goes back more than a hundred years. But for most of that time it was so much in the doldrums as to be practically non-existent. Then, in 1940, it began such a period of development and expansion that it can be fairly claimed that, at the beginning of the Second World War, Army education was reborn. Developments since that date have been described and criticized in *Nature* from time to time ; a comprehensive review of the entire project during the latter part of, and since, the Second World War, by General Lloyd, was published in *Nature*, **158**, 775, 821, December 1946. His present statement brings the review of Army education up to date.

Naturally, in 1940, Army education suffered its new birth pangs, and for some time afterwards experienced the staggers of adolescence. Difficulties were encountered by this stupendous undertaking, and stumbling-blocks had to be removed. There was, of course, considerable criticism ; and from this arose one of the greatest problems, for, sympathetic criticism aside, there were too many men (and women) who, though educationists and educators in civilian life, were unable to grasp the fact that in Service life, especially during war-time, actions and attitudes must be different. Men in the Army (no matter whether at war or at peace) are first and foremost soldiers and have to be trained as such : their education is, of course, happily an integral part of this ; but whatever ingenious schemes are adopted the soldier is not so advantageously placed as the university student. It must be a relief to the Army education authorities to realize that the time has now come when most of those who found it difficult to adapt themselves to such exacting conditions as Army life must inevitably inflict on the cultural life have either been able to do so now by learning and appreciating military methods or have themselves returned to the comparatively easier civilian life and work.

In spite of carping (as opposed to constructive) criticism, real mistakes, and the many problems peculiar to military organisation, however, the adolescent period of the new Army education is quickly passing, and it is now approaching sturdy manhood as evidenced by this new Scheme, which is obviously based on recent past experiences. Thinking

* Army Education Scheme (Interim Period). Army Council Instruction. Nos. 1076 to 1083 of 1947. Circulated down to Companies, Batteries and Equivalent Units. (The War Office.)

over the nurturing of this healthy though sometimes intractable organism, one calls to mind the valuable work of the Central Advisory Council for Education in H.M. Forces, the secretary of which is Dr. Basil Yeaxlee, reader in educational psychology in the University of Oxford, and the wise guidance, sympathetic encouragement and practical assistance of such men as Sir Ronald Adam, then an active soldier and eventually adjutant-general to the Forces, now president of the British Council; Sir Philip Morris, himself at one time director-general of Army education, now vice-chancellor of the University of Bristol; and there were others. Since 1945, Major-General Cyril Lloyd has been director of Army education, and there can be no doubt that its satisfactory progress is due mainly to his efforts.

Despite retrenchments and economies, the loss to civilian life of valuable personnel, and the peripatetic nature of Army units, Army education has been wisely kept as a vigorous and integral part of Army life. In view of compulsory national service, this is as it should be, of course; but we have no doubt that the present position was assured only by untiring efforts, tactful judgments and astute appraisement of personnel on the part of those most directly concerned, for there has been, and still is, apathy towards Army education among certain leaders both inside and outside the ranks of the Army.

It is good to note that close and congenial relations exist between the Army Education Directorate, the Ministry of Education and the local education authorities. This will undoubtedly prove to be of advantage to all three. We have no doubt that the universities and technical and other colleges will play their part when requested to do so. The Army has also ensured that future developments in civilian education and recent advances in educational science will be utilized for the stimulation of its own educational projects through the medium of an Educational Advisory Board which is composed of leading British educationists.

It is to be noted with satisfaction also that the authorities recognize that, though during his period of national service a soldier's military training is of paramount importance, the majority of these men will be returning to civilian life after their short period of service. This is provided for in the new scheme through individual and vocational education. So, except for the more advanced academic students, there seems to be no reason why a man should not continue his education through his period of national service. One recognizes a blemish on the organisation of civilian education when one learns that even now Army education authorities have to deal with youthful illiterates; it seems absurd that for men and women of eighteen years of age the Army education scheme has to provide a 'Preliminary Education' for those who are backward; yet such is the case, and it is to the credit of the Army education authorities that they recognize and are dealing with the problem.

There is nothing to which serious objections can be raised so far as the curricula for primary, general and individual education are concerned, though we still view with some misgiving the considerable emphasis placed by the Army Council on citizenship and current affairs. It may be safely assumed that this is in accord with the present-day fashion in adult education. Yet we believe that citizenship is best dealt with in the ordinary subjects of the curriculum, especially literature, history, geography and science, and not lifted out of the general scheme and treated as a separate subject. Thus presented, all these subjects would inevitably lead on to present-day social problems and sociology, which in themselves form the ideal background for the training of good citizens. Current affairs can conceivably be a valuable discipline in adult education if only a dispassionate choice were assured; but all too frequently it is political affairs which are chosen (we cannot, for example, conceive of many teachers choosing at the end of September the annual meeting of the British Association as a 'current affair'), and these, especially during discussions, lead on to arguments based on party politics, irrational and sometimes even ill-informed bias, and frequently gusts of emotion.

Apart from this undue emphasis, the Army education authorities have shown themselves familiar with modern educational trends in their choice of academic, technical and vocational subjects. Science plays its part; and here the authorities wisely bear in mind that their purpose in general is not to train scientists, but to see that the men and women in their care are given an opportunity of learning what science really is and what it is doing. The general tendency is to begin with science in everyday life and thence leading on to science in social life. Thus the impact of science on society and the social function of science find a place in the general Army educational programme.

The British Army, even in peace-time, is widely scattered at home and abroad. The task of organising its education is very difficult. Isolated units, apathetic commanding officers, sparsity of trained instructors occur here and there, and raise problems which have to be faced. There are, therefore, problems that no school or university, not even the most widely spread and rural county authority, ever have to face. Yet these are now being attacked in a manner that should inspire the admiration and goodwill of all other educationists. There is still much to be done, apart from meeting the criticisms of those whose views are too personal or parochial to enable them to envisage and appreciate the scheme in its entirety. But the past seven years have proved beyond doubt that the British Army is taking the education of its men and women seriously and has placed responsibility for it in the right hands.

This scheme for the interim period augurs well for the future schemes which will be devised for the educational needs of the peace-time Army—schemes which we understand will be progressively introduced so that adult education can be fully implemented when the Army has reached its final peace-time shape and composition.

UNIVERSITY REPRESENTATION IN THE HOUSE OF COMMONS

BY the terms of the Representation of the People Bill now before Parliament, it is proposed that parliamentary representation shall be limited solely to county and borough constituencies, each returning a single member; and that residence shall be the qualification for the franchise, with the usual conditions that electors must be British subjects of full age and not subject to any legal incapacity to vote. Hence the university constituencies would be abolished.

For some generations, there has not been any kind of redistribution of seats in the House of Commons, much less of redistribution by way of destroying one kind of seat, without preliminary attempts to find the maximum agreement. On this occasion there has been a Speaker's Conference, which recommended, without a dissentient voice, the retention of the university seats. Although all the supporters of the single transferable vote agreed that it was not applicable to constituencies with less than three members, yet it was preserved for the two-member university seats precisely to make it plain that it was desired to give the second largest party among university voters every possible advantage. So recently as October 1947, the present Lord Chancellor, when promising a Bill for electoral reform arising out of the recommendations of the Committee of Electoral Registration, the Speaker's Conference, and the Committee on Electoral Law Reform, proclaimed that if his questioner was familiar with all the proceedings in those Committees, he would be able to forecast precisely what the Bill was going to do. It is difficult to see how Speakers' Conferences can in future be as friendly and non-partisan as they have not unsuccessfully striven to be in the past, if now those parts of the last Conference's recommendation which seem electorally damaging to the present majority in the House of Commons are to be treated so cavalierly.

University constituencies have existed in Britain for about a dozen generations; there is a vague pre-history even older than that. For what antiquity is worth, therefore, they have a title to consideration. Of something the same nature is the argument that university parliamentary representatives are now all that is left to keep alive the old principle of representing corporations. It was the rural corporations which were counties, and the urban corporations which were boroughs, that were represented in the old House of Commons; and to them James I added the 'learned corporations', that is, the universities.

Looking down the list of those who have represented, for example, the University of Cambridge, it is easy to pick out distinguished names. Very early, Cambridge elected Francis Bacon. John Coke, Thomas Eden, a couple of Cromwells, George Thurloe, George Monk followed within half a century; and in the next generation, Sir William Temple, Sir Isaac Newton, and others scarcely less memorable. In the eighteenth century, a very high proportion indeed of the Cambridge men were lawyers of the highest distinction. Towards the end of that century, William Pitt long sat for the University, and after him there were Palmerston, Copley (Lord Lyndhurst), Speaker Manners-Sutton, and others who held high office as ministers or judges, or were men of eminence in more purely intellectual fields. The Oxford list also includes many distinguished names; and the other universities represented in Parliament have, considering the relative lateness of their entry into the field, a scarcely less significant record of service in the House of Commons.

The arguments against university representation can be reduced to two only. One is that it produces members whom the objector dislikes on personal or political grounds. This argument could be valid only if it be agreed that the members elected have been such as the House of Commons would have been better without. The many distinguished men, and more recently women, who have entered Parliament as members for the universities provide sufficient answer to this; it can scarcely be questioned that the House of Commons would have been much the poorer without them.

The other argument used against university representation is that it interferes with strict arithmetical proportion between the House of Commons and the voting public. But does anyone take this principle seriously in these times? It is generally admitted that from the arithmetical point of view Scotland and Wales are properly over-represented, and should continue to be over-represented, in virtue of their national and historical significance. (Incidentally, a similar argument might well save the City of London, which is also threatened with the loss of its representatives.) It is agreed also that the difficulty of representing remote and thinly populated districts is such that they ought to have more members than arithmetical justice would confer upon them; and accordingly, as the House of Commons is at present constituted, and as the Bill now before the House proposes to reconstitute it, there is variation of the number of constituents needed to return a member, in accordance with remoteness from London and with excessive area. Indeed, anyone who really thinks the purely arithmetical principle the necessary dominant in the question is almost driven to proportional representation, with large numbers of seats per constituency, say six or seven, and to annual parliaments, if not to the right of recall by electors.

University members hold less than 2 per cent of the seats in the House of Commons, and nobody suggests that they should hold more. In the two- and three-member university seats, election is by a kind of proportional representation which gives special advantage to the second largest party. It is not reasonable to suggest that any great section of opinion need despair of carrying a university seat, unless it has a very remarkable faculty for antagonizing university graduates. Indeed, there has been no attempt to organise university representation in a tightly partisan way. Any such attempt would almost certainly be doomed to defeat by opinion among

graduates, and also, as already indicated, by the method of election in two- and three-member seats.

In any event, it cannot be a bad thing that there should be a few constituencies which are not local, in which the voters are scattered all over the country and indeed all over the world, and in which the rival candidates compete in long, reasoned statements rather than in slogans. *The section of a university constituency resident overseas is a peculiarly important part of the nation. There is little doubt that a very high proportion of British subjects in important posts in Asia and Africa are university graduates. Very many of these men and women have no vote in other constituencies.* A very high proportion indeed of them know their university member, or at least know the sort of man he is, and have friends who do know him directly. There is here a channel of communication between Westminster and Whitehall on one hand, and British subjects serving in public or private posts abroad on the other hand, which has a great and growing value.

The universities of Britain are the highest educational institutions of the country. It is not necessary to think their officers and representatives are overcomplacent about them; but they may fairly claim that the universities compare favourably, both in the quality of performance of their function and in public opinion about it, with other great institutions and productive agencies. Yet it is certain that the political and economic tendencies of the last two generations have made it far more difficult for universities and colleges to be independent and self-subsistent than they used to be, and far more difficult also for them to hope for re-endowment from any extra-governmental source. Incidentally, in connexion with Government grants to the universities, it was as well, during the latter years of the War and in the period immediately following, that there should have been men in close touch not only with the leading figures at the universities, but also with Westminster and Whitehall, who preserved a critical faculty about blithe presumptions that in the immediately post-war period there would be, easily and of course, more and better education, with much more money and much more material at its disposal. Surely we are now at a moment when it is peculiarly evident that higher education, and especially the highest education, should have some guarantee of direct two-way communication between the universities and Westminster otherwise than by the relations between the official academic authorities and the Treasury and other Government departments, good and valuable though such relations are. The universities of Britain, as the culminating point of the educational system of the country and also as the symbols of a broad and cultured outlook on human affairs, are likely to increase in importance in the years to come. As such they are entitled to seats in the House of Commons, quite apart from the influence on the course of debate exerted by men of the type sent to Westminster by the universities. No satisfactory case can be made for the abolition of the university franchise.

A SHORT HISTORY OF SCIENCE

The Growth of Physical Science

By Sir James Jeans. Pp. x + 364 + 14 plates. (Cambridge: At the University Press, 1947.) 12*s.* 6*d.* net.

THE reputation of Sir James Jeans as an interpreter of science for the educated layman stands deservedly high. His wide interests and broad sympathies, aided by an exceptional power of exposition and a lucid and dignified prose style, have won him a very considerable circle of readers; and his writings have done much to substantiate the claim that science, in spite of the technicalities with which it is necessarily surrounded, has a cultural value, and some right to be regarded as one of the 'humanities'. The strength of the reaction provoked by his books from the philosophers on one hand and from the upholders of the strictly utilitarian conception of science on the other may be taken as a measure of his achievement.

In "The Growth of Physical Science", his last volume, the proofs of which were revised by him just before his death in September 1946, Sir James Jeans breaks fresh ground. It is true that, in the last chapter, he brings us again to the frontiers of knowledge; but he is, in the main, concerned to trace the long and devious route by which the physical sciences have advanced to their present position. "I have thought," he writes in the preface, "I might usefully try to describe the main lines of advance of physical science, including astronomy and mathematics, but excluding all points and side-issues, in language non-technical enough to be understood by readers who have no scientific attainments or knowledge." The last clause must not be taken too literally. It is, of course, scarcely possible to discuss the history and development of mathematics intelligently without the use of some mathematical symbols and processes. The reader, particularly in the earlier chapters, will find it necessary to evoke some memories of his school 'maths', and may, incidentally, find that subject glowing with an interest it had not awakened before. Nor can the reader "with no scientific attainments" be promised that he will understand every word of the highly condensed account of the era of modern physics contained in the last chapter. He may find himself confessing (like Alice after reading the immortal "Jabberwocky"), "Somehow it seems to fill my head with ideas—only I don't know exactly what they are". Even this degree of apprehension may be well worth while; it is, after all, with the history rather than the details of scientific discovery that the book is concerned.

It is no easy matter to compress within some three hundred and sixty pages the history of three great sciences; to do full justice to the genius of the ancients, facing absolutely new problems with nothing to guide them, and yet to give due space to the spate of discoveries and theories of modern times; to estimate the relative historical importance, say, of a Pythagoras and an Einstein, of Archimedes and Faraday. In the present volume roughly one third of the space is concerned with classical times, ending with the burning of the library at Alexandria; another third brings us to the end of the age of Newton; leaving some one hundred and thirty pages for the two hundred and fifty years since that date. One cannot help feeling that the pace, towards the end, is becoming a little breathless. No one but Jeans could have condensed so much into so small a space without reducing his text to a mere catalogue; and

the book is certainly not that, even when it is most condensed. One can only wish that Sir James, with his wide sympathies and penetrating judgment, had dealt with this final quarter of a millennium more nearly on the scale of the earlier chapters of the book.

Science is an activity of human beings and its progress must be influenced by, and in turn must influence, the religion, the philosophy and the social structure of its age. Any true history of science must take these interactions into account, and Jeans has dealt with them with the objectivity and impartiality which one should expect from a man of science, but which have been conspicuously lacking in some recent popular writings on the subject.

"The Growth of Physical Science", though not altogether free from historical errors, is a very human and a very fascinating volume, which holds the reader like a well-told tale. It is possible that the general diffusion of an understanding of the methods and purpose of science, which all regard as urgent, may be most easily attained through a study of its history. If, as we are told, a study of the past holds the clue to the present, it may be that in the history of science we may find some hints for a solution of some of those vital problems with which the dominance of scientific discovery confronts our civilization to-day.

J. A. CROWTHER

CALCULUS BASED ON THE FUNDAMENTAL CONCEPT OF NUMBER

Differential and Integral Calculus

Functions of One Variable. By Prof. Francis D. Murnaghan. Pp. x + 502. (Brooklyn: Remsen Press, 1947.) n.p.

IN the evolution of the teaching of mathematics, many thoughtful teachers frequently examine critically the basic concepts of the subject in order to make quite sure that the edifice they are constructing is sound and stable. As Prof. Bell[1] points out: it may seem strange "to build up vast systems of knowledge without seeing first whether the foundations will bear the superstructure, and mathematics did precisely that". This is especially true of the calculus, and experience has often shown that, in the case of non-specialist technical students, the calculus is sometimes regarded as a system of purely formal operations. Indeed, Prof. Murnaghan declares in the preface of the book under review: "Many teachers seem to feel, and have no hesitation in expressing their feeling, that it is impossible to teach calculus correctly. The best one can do, they claim, is to give some idea of what the subject is about and to impart, by repeated drill and practice, proficiency in the manipulative details of the subject." It may be remarked here that this refers obviously to the teaching of calculus in America. Is such an experience shared by English teachers? Undoubtedly, many cases could be cited where practical students become fairly expert in manipulative technique without a real understanding of the meaning and necessity for the operations involved. The subject thus becomes purely formal instead of an intelligent aid to calculation.

A brief survey of the history of the concepts of the calculus reveals that many of our great mathematicians left gaps to be filled. As Carl Boyer[2] states: "Although it was Cauchy who gave to the concepts of the calculus their present general form, based upon the limit concept, the last word on rigour had not been said, for it was Karl Weierstrass who constructed a purely formal arithmetic basis for analysis, quite independent of all geometric intuition. . . . In order to secure logical exactitude, Weierstrass wished to establish the calculus (and the theory of functions) upon the concept of number alone." In the great work of Cauchy, two conspicuous failures are noticeable—his omission to define precisely the notion of an infinite aggregate, as well as that of number. Here, it seems, we reach the bedrock of the matter, and it is upon this idea that the present book has been written. To quote again from the author's preface: "We have tried to teach the science of calculation, i.e., of finding the numerical values of functions, without taking the trouble to explain what a number is". The fifteen chapters of the text are thus based upon a lucid discussion in the opening chapter, occupying 48 pages, on numbers, variables and functions. This leads to differentiable functions, the calculation of derivatives, maxima and minima, the theorem of the mean, inverse functions, length of arc, trigonometric functions, anti-differentiation, definite integrals, plane curves, infinite series, tests for convergency and the application of integration. Special emphasis is placed on differentiability rather than on the derivative, and differentiable functions are treated before continuity is considered. Null functions form the basis of the study of limits, and the exponential function is introduced as the inverse of the logarithm.

There is no doubt that "the calculus is the greatest aid to the discovery and appreciation of physical truth; but the basis for this success in all probability is to be found in the fact that the concepts involved were gradually emancipated from the qualitative preconceptions which result from our experiences of variability and multiplicity"[3]. Again, as J. W. N. Sullivan[4] remarks: "A great deal of modern mathematics is the outcome, not of the merely formal development of what was known before, but of a profound critical examination of the foundations of the science".

Prof. Murnaghan's treatment of the subject is thus designed to give the student a deeper understanding of its methods by founding it upon basic concepts. It is therefore a judicious mixture of theory and practice, with the result that many of the explanations have to be very detailed which, in places, renders them somewhat lengthy. On reading through the text, one wonders whether such a treatment will not tend to detract from the interest that should be developed. The whole course is logically sound and marks a commendable break away from the routine methods; but, after all, too great an emphasis upon fundamental concepts is not always an effective introduction to any subject. As many experienced teachers may well ask: Is it not better to defer the consideration of fundamental refinements until a later stage when a student has learned to appreciate some of the difficulties arising from the theoretical basis of the calculus?

Nevertheless, the book may be recommended as a distinct contribution to the subject; but whether it will fulfil its lofty aim, only experience and time will show.

F. G. W. BROWN

[1] "The Queen of the Sciences", p. 130.
[2] "The Concepts of the Calculus", pp. 284–5.
[3] "The Concepts of the Calculus", p. 309.
[4] "The History of Mathematics in Europe", p. 109.

THE PRESENT OUTLOOK IN ARMY EDUCATION

By MAJOR-GENERAL CYRIL LLOYD, C.B., C.B.E., T.D.
Director of Army Education

THE experience gained by Army educationists between 1920 and 1939, the story of Army education during the Second World War and release period, together with the broad principles of post-war development, have been the theme of previous articles (*Nature*, **158**, 775, 821, December 1946). The contrast between the condition of education in the Army after the First World War and after the Second is clearly marked. It is the difference between the newly formed Army Educational Corps struggling against apathy, suspicion and even hostility, and a Corps recognized as an integral part of the national system and a pioneer in the field of further education.

The educational obligation of Service authorities has been defined in the National Service Act of 1947, in which a direct cross-reference to the Education Act of 1944 establishes the full responsibility of the Army to provide further education for all service personnel and to co-operate to the full with all local education authorities to ensure adequate facilities for that education.

The issue of Army Council Instructions authorizing the implementation of a definite plan for Army education which shall supersede that of the release period brings to maturity a scheme which has been in process of preparation for nearly two years. Each stage of the plan has been considered and endorsed by the Army Education Advisory Board under the chairmanship of Sir Philip Morris. The general plan has been designed to meet the educational needs of the peace-time Army and to form an integral part of its training and working programmes. The present transitional stage between the Army Education Scheme for the release period and the greater development towards this post-war scheme is to be known as the interim period.

The object is to provide for the soldier that which is required, educationally, to improve him both as a soldier and as a citizen and to meet his needs as an individual. As part of the national system, its aim is integrated as closely as possible with civilian education, and care has been taken to weld into the scheme provision for both the national service man and the regular soldier. Hitherto the machinery of the Central Advisory Council for Adult Education in H.M. Forces has been instrumental in securing civilian assistance for Army education. Negotiations are now proceeding which will, it is hoped, secure the continuance of this valuable work on a basis suited to the conditions of the peace-time Army on one hand and civil education on the other. Arrangements have also been made with the Ministry of Education for His Majesty's inspectors to co-operate in an advisory capacity with the military inspectors of the Directorate of Army Education, thus placing their experience and knowledge at the disposal of the Army.

The main types of education which will be provided are described as (*a*) general education and (*b*) individual education. The vast majority of the men and women entering the Army are catered for by general education. The soldier must first acquire that fundamental knowledge without which he can be neither an efficient soldier nor a satisfactory citizen. For the first six weeks he will receive instruction for two hours a week in current affairs and citizenship; thereafter time will be increased to three hours weekly, and English, mathematics, history/geography and general science will be added to the curriculum. Courses will be graded in three standards and there will be variations and exemptions for men above average, who will be catered for in ways appropriate to their particular educational needs. At the end of a year's service the national service man will leave the Army; but the regular soldier who remains will continue this work for four hours weekly during a further twenty-four months, after which only current affairs and citizenship will be compulsory, though he may continue his education in working time if he so desires.

The syllabuses are progressive, and these, together with specimen tests of attainment, are to be found in the General Education Handbook. This Handbook was designed for the use of instructors and, used with flexibility and careful selection, it will provide a guide for the establishment of a continuous liberal course of study. The approach in all subjects is adult and is based on the experience and interest of the individual.

General education will be carried out in working time; its counterpart, individual education, will be done in the soldier's off-duty hours in unit classes, educational centres, and Army colleges, under arrangements made with civilian education or by means of the War Office Correspondence Course Scheme. The soldier may undergo courses or pursue activities either to improve his prospects in civil life, or to satisfy his cultural needs or his desire for profitable leisure-time employment. An important aspect of individual education will be the resettlement education of the regular soldier and the development of a resettlement advice service. These activities are additional to continuation studies for those individuals who have reached the standard of School Certificate or other equivalent examination and whose guided reading periods will be catered for by the unit or higher formation reference libraries.

Men of exceptionally low standard will, immediately after enlistment, be given a special full-time course at a preliminary education centre to fit them to join the main stream of general education at a later date. The Royal Army Educational Corps has had considerable experience in combating the problem of illiteracy and as a consequence has evolved practical methods which, combined with sympathetic attention to the personal needs of each individual, have been found to produce a remarkable improvement in the reading age and general attitude of the backward adult.

The scheme will be staffed by full-time Royal Army Educational Corps instructors on an overall scale of one per 240 men, assisted by part-time instructors provided by units. The work of instructors will be supervised by R.A.E.C. officers, of whom one will be allotted to every 2,400 men. Each supervising officer will act as a travelling headmaster, exercising control over the work of instructors in a group of units. The smoothness of administration and organisation of the Corps is the duty of the R.A.E.C. staff officers provided in the War Office and on headquarter staffs. In the unit it is the commanding officer, with the assistance of his unit education officer, who is responsible for the educational progress of his men, and only through his co-operation can any plan succeed. The regimental officer is responsible for conducting discussions on current affairs and will always be chairman of such discussions.

Many of the present R.A.E.C. instructors are young in experience and, although graduates and trained teachers are to be found within their ranks, it will take time to build up a corps of instructors with a predominance of experienced and academically qualified personnel. The other major difficulty which only time can resolve is that of ensuring continuity of instruction. This will only be fully achieved when the Army as a whole becomes more stable in composition, so that the soldier's service is spent in two or three units at most. Despite these limitations, certain aspects of the plan are already in operation and working well; notably, perhaps, the work with illiterates at preliminary education centres. Here the adult approach through activity is reviving and stimulating interests and skills which have in some cases been dormant for years and in others barely existed. Much valuable work is also being done in the initial stages of the soldier's service, both in the special attention paid to current affairs and citizenship during basic military training, and in the care with which, before being sent overseas, the soldier is briefed as to conditions in the theatre to which he will go and in the historical, geographical and cultural background of the countries concerned. In this latter connexion, a comprehensive series of teaching aids in the form of posters, study briefs, films, film strips, exhibitions, etc., has been prepared and is already in production. In the case of more advanced students, too, there are indications that both unit and centralized library facilities are being used, there is an encouraging demand for correspondence courses, and in many areas civilian resources are being used to the full.

Stated simply, Army education shows to serving men and women how they fit into society as soldiers and citizens, and indicates how individual experience and self-expression may best contribute both to the development of the individual and to the common good. It is not only the future of the Army which is staked upon the training of young service men and women; as the result of their service experience they should return to the civilian community better informed, more self-reliant, in better shape physically, and better equipped both for work and play. In this process it is the task of Army education to give the soldier something which he will recognize as being of permanent value whether he thinks of himself primarily as a worker, as a citizen, or as an individual.

STRUCTURE AND PHYSICAL PROPERTIES OF METALS

THE autumn meeting of the X-ray Analysis Group of the Institute of Physics, held in Birmingham during November 20–21, 1947, was devoted to metals and alloys. The place of X-rays in their study was put in proper perspective: in some of the researches described they provided the main method of attack; in others they were subsidiary.

Dr. W. H. Taylor opened the first session by giving a general account of transformations, referring to the importance of the study of simple alloys as a basis for the study of the more complicated commercial ones. He instanced the order–disorder transformation, and pointed out that X-ray methods permit the study of long-range order, whereas the relationships between near neighbours are physically more significant. The use of crystal-reflected radiation may overcome this disadvantage by allowing changes in background scattering to be observed before ordinary superlattice lines appear[1].

Dissociation has also been studied[2] in the alloy Cu_2FeNi_2. X-ray powder-photographs show 'ghosts' at the sides of the main diffractions, and these are interpreted as evidence of a pseudo-periodic structure due to the incipient dissociation into two phases of similar structure.

A still more detailed investigation has been made of duralumin[3]. Streaks on Laue and oscillation photographs of a single crystal were ascribed to the segregation of copper atoms on sheets parallel to the (100) planes; the break-up of these streaks into spots showed that a metastable structure, $CuAl_2$, was forming, 'keyed' to the main lattice; this structure finally transformed to the stable $CuAl_2$ phase. Thus the changes occurring in age-hardening have been followed in great detail by means of X-rays.

Dr. H. Lipson gave an account of recent work on the alloy $AuCu_3$. Alloys of this type can have a domain structure, and this results in broadening of the superlattice lines with respect to the main lines. Attempts to determine the sizes of the domains from the breadths of the lines, however, yielded inconsistent results[4], and a further condition—for example, that the gold atoms tend to avoid each other[5]—must be imposed. The diffraction effects produced by this condition are unusual; in reciprocal space the superlattice reflexions are represented by disk-shaped volumes of differing orientations[6], and attempts have been made to detect these by means of oscillation photographs of single crystals. MacGillavry and Strijk[7] were unable to find the effect, and claimed that all the spots had cubic symmetry. Edmunds, Hinde, and Lipson[8], with a much smaller crystal, found it, and so did Guinier[9]. Quantitative confirmation, however, is still required, but the investigations promise to provide interesting evidence about transformations on the atomic scale.

Dr. A. J. Bradley presented a different approach to the study of alloys—that of metallography. He emphasized, however, the importance of previous study by X-rays, and gave as an example the system Fe-Ni-Al, in which the results of Köster[9] had been shown to be wrong because the possibility of three-phase regions had not been envisaged[10]. Although slower than the X-ray method, the microscopic method enables the dispositions of the various phases to be studied; Dr. Bradley showed many beautiful examples of photomicrographs of magnification up to 4,000, and claimed to be able to distinguish between ordered and disordered structures. The microscope is of particular value when changes in temperature are to be considered; X-ray methods fail in the Fe-Ni-Al system because high-temperature structures tend to transform on quenching. A high-temperature camera is required, and progress depends upon the production, in the near future, of a suitable instrument.

Mr. H. J. Goldschmidt showed how Dr. Bradley's results had enabled him to interpret some of the X-ray data he had obtained on the permanent-magnet alloys, 'Alnico' and 'Alcomax'. He found 'ghost' lines similar to those given by Cu_2FeNi_2, and said that the pseudo-periodic structure they indicate could be related to some of the microphotographs shown by Dr. Bradley. He also showed how reactions can take place even when the final state is the same as the first, and attributed the changes to Ostwald's law of successive reactions.

In the second session, Dr. G. V. Raynor gave a lecture on the "Electron Theory of Metals". Although this theory is only a part of a much greater whole, in some systems its effects outweigh others; for example, in the copper–zinc system the atoms are so similar in other respects that their difference in valency leads theoretically to results of practical importance.

In metals, the valency electrons are shared by each complete crystal grain—an extreme case of covalent binding. These electrons still have to obey Pauli's exclusion principle that only two (of opposite spin) can occupy the same state; thus the total energy of the valency electrons is quite large, despite the fact that, because of the size of the crystals, the differences in energy between the various states is vanishingly small. The energy is such that the majority of electrons have velocities of the order of 10^8 cm. per sec.

The periodic structure of metals must, however, also be taken into account, and wave mechanics provides a neat method of introducing it. A particle of mass m and velocity v can be considered as a wave-packet of wave-length $\lambda = h/mv$, and if the particle is an electron with velocity 10^8 cm. per sec., λ is about 10^{-8} cm.—the value for X-rays. Thus the electrons can be diffracted by the lattice in which they are moving, and this is the essential feature of the theory.

Suppose we plot, from a fixed origin, radius vectors representing the momenta of the electrons. The momentum defines the electronic state and thus the space—k-space—is, by Pauli's principle, uniformly populated. Owing, however, to the diffraction mentioned above, the distribution of energies between the electronic states shows characteristic variations. It can be shown that those electrons which satisfy the Bragg equation have momenta that lie on planes in k-space, and these planes outline zones known as Brillouin zones; it can further be shown that electrons in states that lie just within the surface of a zone have energies less than the value $\frac{1}{2}mv^2$ for free electrons. Thus structures in which the occupied states reach almost to the surface of the zone will have less electronic energy and consequently a lower total free energy (other things being equal) than those for which the surface is farther away.

Dr. Raynor showed some drawings of Brillouin zones. That for the face-centred cubic structure is far from spherical; thus the addition of zinc to copper allows the electrons to reach the surface, and the advantage of the depressed energy is utilized; but with further addition of zinc, the energy increases rapidly because the electrons have to be accommodated in the more remote corners. The rapid increase sets in at about 1·4 electrons per atom, in agreement with the solubility of zinc in copper. The body-centred cubic structure is more nearly spherical, and the γ-structure still more nearly so; this, then, explains the sequence and compositions of phases in the Cu-Zn system. In the hexagonal structures that occur in zinc-rich alloys, the nature of the overlap into the second zone is of importance, and Dr. Raynor showed how the variation of axial ratio in these phase fields can be accounted for on the electron theory.

Dr. Raynor concluded by giving an account of the experimental work he is pursuing in order to test further predictions of the theory and to investigate the modifications introduced by other factors.

The final session was devoted to matters of more industrial interest. Dr. T. Ll. Richards described the application of X-ray methods to the study and control of preferred orientation and consequent anisotropy in non-ferrous alloys. The deleterious effect of such anisotropy in annealed copper strip was well illustrated by a pressing in the form of a cup made from the strip; this should have had a flat top, but instead had four pronounced 'ears'. Anisotropy in cold-rolled strip, however, is not necessarily due to preferred orientation; it can be due to structural defects on the planes of maximum resolved shear, inclined at 45° to the rolling direction. This effect was illustrated in a photograph of a strip of considerably over-rolled aluminium alloy.

A preferred orientation of crystals is developed by both hot- and cold-working. In the cold rolling of face-centred cubic metals, for example, the crystal grains tend to orient themselves so that a given plane, for example, (110), is parallel to the plane of rolling, and a given direction in that plane, for example, [112], is in the direction of rolling. Many such combinations are possible[11], but the twin (110) [112] textures are predominant in heavily cold-rolled copper strip. Depending on the magnitudes of the initial grain size, cold-rolling reduction, and the final annealing temperature, the twin textures merge together on annealing[12] to form the single (100) [001] texture, so that the resulting material has almost the anisotropy of a single crystal, with the resultant unwelcome directional properties. A clear understanding of the influence of these factors is necessary for the production of directionality-free strip.

Dr. A. Hargreaves described a corresponding research on rolled magnesium alloy. Since magnesium is hexagonal and thus has one unique direction in each crystal grain, the number of possible modes of reorientation after working is less than in cubic crystals. In practice, it is found that this unique direction [001] is approximately perpendicular to the plane of the sheet, and that the variation (of about 25°) is mainly along the direction of rolling. If, however, the direction of the [001] axis is examined at different depths in the sheet, by means of surface-reflexion photographs from successively etched surfaces, it is found not to be random; it starts at 0° in the surface and increases within the body of the sheet to 15°. This is so for both surfaces, and thus in the body of the sheet there is a mixed orientation of (0001) planes making angles of about 30° with each other[13]. Dr. Hargreaves showed that transmission photographs with a hard radiation would give only an average of these results; the detailed variation with depth would be missed.

Dr. Hargreaves described a moving-film method with which metallic textures could be determined, and pointed out the advantages of obtaining on a single film the information normally obtained only from a series.

Mr. N. F. Astbury read a paper, prepared in conjunction with Dr. Scholefield and Mr. De Barr, on the iron–silicon alloys used for transformer sheets. These alloys, which contain about 4 per cent silicon, have the body-centred cubic structure of α-iron. It is known that magnetic saturation of a single crystal of iron is produced with lowest field-strength if this field is applied in the [100] direction, and thus, if the alloy can be prepared with the [100] direction in the direction of rolling, the magnetic performance in this direction will be superior to that obtained with

randomly oriented material. Thus preferred orientation is sought for, not avoided.

Mr. Astbury described the treatment that has been found to work in practice. He emphasized, however, that other considerations are important; traces of carbon or sulphur can more than cancel out the gains made by the processing.

Several methods are in use for examining the texture; X-ray methods are not necessarily the most useful, since the large grain-size introduces difficulties in obtaining ordinary polycrystalline photographs, and in some cases other methods such as measurement of magnetic or strain anisotropy, or optical reflexion from etch pits, are more informative. X-rays still provide a basis for interpretation of the other results.

Each session of the conference was followed by discussion in which many of the points made by the speakers were enlarged upon. These discussions brought out very well the importance that metallurgists attach to X-ray methods and the interest the X-ray crystallographers have in the metallic state.

H. LIPSON

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GEOLOGY OF THE SALT RANGE OF THE PUNJAB

IN the issue of *Nature* of March 23, 1946, p. 359, I gave a résumé of a "Symposium on the Age of the Saline Series of the Punjab", held at Poona in 1944 under the auspices of the National Academy of Sciences of India (published 1945 [1]). At the time I wrote, a second symposium had already been held on the same subject at Udaipur in 1945 (published 1947 [2]). Page references in the sequel refer to this second symposium.

The point at issue, it will be remembered, is whether the Punjab Saline Series, which commonly occurs beneath fossiliferous Cambrian at the foot of the Salt Range escarpment, is of Cambrian or Tertiary date. The interval between the appearance of the reports of the two symposia has been well employed by the main protagonists, E. R. Gee and B. Sahni. Gee has led two additional excursions to exposures which he considers leave no doubt of the 'natural' superposition on the Saline Series of, in some places, Cambrian Purple Sandstone, and, in others, unconformable Carboniferous Talchir Boulder Bed. His companions have been, at one locality or another, J. B. Auden, J. Coates, B. S. Downward, W. D. Gill, B. S. Lamba, G. M. Lees, E. S. Pinfold, B. Sahni and M. R. Sahni (pp. iv, 95; Gee, Coates, Lamba, Pinfold and B. Sahni have published in the second symposium, though Coates only in the general discussion, p. 240). Sahni, as well as accompanying Gee on the two excursions, has had much to do with mobilizing further palæontological evidence, now published by himself, M. S. Mani, J. Hsü, R. N. Lakhanpal, B. S. Trivedi and R. V. Sitholey (see list of contributors). Furthermore, Sahni has taken advantage of a visit to Britain to give a number of demonstrations (p. xxxix). I shall always treasure the memory of how perfectly Sahni and Pinfold, out-and-out opponents, co-operated on one of these occasions at the British Museum (Natural History) to make certain that those who attended should understand all sides of the question.

Eleven other authors, not mentioned above, have sent in contributions to the second symposium, though for the most part they had not undertaken recent special investigations; and two more, similarly situated, are recorded among those who joined in the general discussion. In what follows I make no detailed attempt to attribute particular ideas to particular authors; but for brevity treat Sahni as representing the Tertiary correlation, and Gee the Cambrian. I also assume that readers can turn back to my previous digest. I confess that I have not reached a firm conclusion; but I do incline to the view that Sahni is correct. I say this in the full knowledge that most of my brother field-geologists will disagree with me.

Let it be granted that so many specimens of the Saline Series have been sampled that we know there is throughout its components (salt, saline marl, dolomite, oil-shale) a quasi-universal distribution of organic debris in the form of almost microscopic dust.

This proposition, advanced by Sahni, does not seem to have been challenged by anyone. It has been argued that the dust may have been introduced into the host-rocks long after the formation of the latter, and may have no more significance for dating these rocks than water or oil commonly found in sandstones. I confess that we have here a conception, so wonderful, regarding subterranean travel of dust, that I shall feel more than compensated for my incredulity if such migration be eventually proved. My incredulity is for the present strengthened by learning that Gee seems as unwilling as myself to invoke migration to account for the contents of certain oil-shales that he accepts as an integral part of the Saline Series (p. 96). "It is agreed," he says, "that the kerogen and free oil is indigenous in the shales, and that it has been derived from either vegetable or animal remains." But he adds: "No evidence of animal remains within the oil-shales has been met with, though many geologists have made an intensive research. What is the evidence of the plant remains that have so far been recognized in these oil shale strata; can they not possibly represent a Cambrian flora?" Sahni's reply is: "Mr. Gee's statement that 'no evidence of animal remains within the oil shales has been met with' evidently refers only to macrofossils. The microfossils described and figured by Messrs. Trivedi, Mani and Lakhanpal and by myself are on the table, open to inspection, along with the rocks from which they were prepared" (p. 246). Another, though less potent, argument against the subterranean dust-diffusion hypothesis is that, in three localities tested in detail, "while angiosperm and insect remains always occur in the Saline Series rocks (that is, below the suspected thrust-plane) there is no trace of these groups in any of the samples taken from the overlying Palæozoic beds, respectively the Purple Sandstone, the Lower Gondwana shales within

the Productus Limestone, and the Talchir shales in the Talchir Boulder Bed" (p. 245; also pp. xviii, xl, 92). Of course, Gee, Sahni and everyone else recognize that the saliferous members of the Saline Series are peculiarly liable to subterranean contamination from without. The only difference of opinion is as to the possibility or impossibility of quasi-universal contamination by introduced dust.

Let it be granted that the dust found everywhere in the Saline Series includes so many examples of recognizable debris of conifers, angiosperms and insects as to be on the whole clearly post-Cambrian.

This second proposition I am prepared to take as a working hypothesis from Sahni and his co-workers. I admit that it involves two separate debatable sub-propositions:

(1) Sahni and his co-workers are certain that the dust particles, which they recognize as remains of conifers, angiosperms and insects, are unmistakable. They publish numerous illustrations, some of them photographs. If botanists and zoologists are withholding criticism out of regard for the authors, they are doing a disservice to science. Gee has asked whether the chitinous dust might not have come from trilobites, rather than insects, and has received an apparently satisfactory answer (pp. 233, 235).

(2) Sahni and co-workers are certain that the particular dust particles, which they identify as bits of conifers, angiosperms and insects, have the same wide distribution as the organic dust as a whole. It might otherwise be suggested that such identifiable material is probably in small proportion and reasonably assignable to contamination. This idea seems to be implicit in Gee's question as to whether the organic remains in the oil-shales might not present a special problem (p. 96), and prove free from post-Cambrian types; but the answer given by Sahni and co-workers is clear, for they maintain that remains of conifers, angiosperms and insects do occur in the oil-shales (pp. ix, xvii, xxii, 53, 187, 204, 205, 207, 220).

Let it be granted that Gee has demonstrated, on three occasions to first-class audiences in the field, exposures which seem to prove that the Saline Series is 'naturally' overlain by unquestionably Palæozoic formations.

Five of Gee's companions have openly adopted his interpretation. Only Sahni himself has said in print that he has seen and disbelieved. The evidence derives in part from lack of manifest disturbance at the contact, and in part from contained fragments in the base of the Talchir Boulder Bed, where this latter happens to be the lowest member of the overlying succession.

Above are stated the three assumptions which for the time being guide my conclusions. I think Sahni is right in interpreting the organic dust in the Saline Series as wind-borne, and contemporaneous. Accordingly I think that the apparent sub-Cambrian stratigraphical position of the Saline Series is misleading. I realize how seldom a major thrust can escape detection in a non-metamorphic, well-exposed succession; but I do know one case in Scotland, that of the Kishorn Thrust, a mile south of Broadford, where Torridon Sandstone is brought on to Durness Limestone in such a manner that any one of us might be deceived if he did not know the answer in advance. Let us hope that further research will soon put the Salt Range problem beyond dispute, one way or the other.

Since this review was written, I have read an extremely important letter by A. K. Ghosh and A. Bose (*Nature*, December 6, 1947, p. 796), in which the discovery is announced of plant dust of apparent post-Palæozoic type in the Salt Pseudomorph Beds. These beds intervene between the Talchir Boulder Bed, above, and the fossiliferous Cambrian, below, instead of underlying the latter as does the Saline Series so far discussed. The elaboration of this find may well lead to decisive results. At first sight it seems rather to weaken Sahni's position.

In conclusion, it is right to express admiration for the organisation displayed by the National Academy of Sciences of India. Perhaps one suggestion may be proffered. Readers would greatly appreciate guidance from page headings.

E. B. BAILEY

[1] Symposium on the Age of the Saline Series of the Punjab, *Proc. Nat. Acad. Sci. India*, **14**, Pt. 6, i–xxxii, 205–334, 9 plates, 29 text-figs. (1945). Price, including postage, Rs. 4/8 (India); Rs. 5 (foreign).

[2] Second Symposium, *Proc. Nat. Acad. Sci. India*, **16**, Pts. 2–4, i–i, 29–257, 45 plates, 44 text-figs. (1947). Price, including postage, Rs. 12/8 (India); Rs. 15 (foreign).

SIR CHARLES SHERRINGTON AND DIPHTHERIA ANTITOXIN

AT a recent informal gathering of some men of science an important matter of scientific interest was brought up by Dr. A. N. Drury, director of the Lister Institute, recording an incident in which Sir Charles Sherrington had played a part more than half a century ago.

The incident concerned the very first occasion on which diphtheria antitoxin was made in England. Dr. Drury exhibited one of the hooves, suitably mounted, of "Tommy", the first horse to be injected in England with diphtheria toxin with the object of obtaining diphtheria antitoxin for clinical use; and he explained how the Brown Institution came to be associated with the British Institute of Preventive Medicine—as the Lister Institute was then called—which had accommodation for small animals only in the kitchen of the private residence in which it was housed. Dr. Drury described how "Tommy" was stabled at the Brown Institution, and how that, here, Dr. Armand Ruffer, then secretary of the British (now Lister) Institute, and Sir Charles Sherrington, who was at that time professor-superintendent of the Brown Institution, made those first injections and withdrew those samples of blood which yielded the first British-made diphtheria antitoxin. Listeners were also interested to learn that "Tommy's" performance as an antitoxin-producer would rank high even at the present day. Many other attendant circumstances of the incident and the time (August 1894 and the later months of that year) were reported by Dr. Drury, among which may be mentioned the lively interest of Sir Joseph Lister (as he then was); the sending of diphtheria antitoxin from Paris to be tried on patients in England pending the material from the horse "Tommy" and, no doubt, other horses immunized by Dr. Ruffer and Sir Charles Sherrington, becoming available; Pasteur's interest and concern that those attempting its preparation in England should benefit by the experience of those colleagues in France who had succeeded in preparing this entirely new type of medicament; and the clinical experience of English medical men who were privileged to use these early preparations. A letter from Dr. Roux of the Pasteur Institute, and others from practitioners who used the antitoxin, were read and exhibited.

Dr. Drury's clear exposition of this historic event, and the unique character of the exhibits connected with it, aroused the greatest interest, and it was agreed that Sir Charles Sherrington's interest would be even greater. A letter was accordingly written and the following is an extract from his reply dated November 15, 1947:

". . . Thank you for kindly writing. Yes, the story was just as you say; except that dear Ruffer's first name was *Armand*. Poor fellow, he was torpedoed and drowned by the Germans in the 1st world war. He was brother-in-law to Bouchard of Paris, the leading French physician in his line.

"The story of the horse at 'the Brown' had a dramatic sequel which perhaps Dr. Drury has not heard; if he has, he will, I hope, forgive my telling it; it may interest you. Ruffer and I had been injecting the horse—our *first* horse—only a short time. We were badly in the dark as to the dosage to employ, and how quickly to repeat the increasing injections. We had from it a serum partly effective in guinea pigs. Then, on a Saturday evening, about 7 o'clock, came a bolt from the blue. A wire from my brother-in-law in Sussex. 'George has diphtheria. Can you come?' George, a boy of 7, was the only child. The house, an old Georgian house, 3 miles out of Lewes, set back in a combe under a chalk down. There was no train that night. I did not at first give thought to the horse, and, when I did, regretfully supposed it could not yet be ripe for use. However, I took a cab to find Ruffer. No telephone or taxi in those days—'93 or '94. Ruffer was dining out. I pursued him and got a word with him. He said 'By all means you can use the horse, but it is not yet ripe for trial'. Then by lantern-light at 'The Brown' I bled the horse into a 2-litre flask duly sterilized and plugged with sterile wool. I left the blood in ice for it to settle. After sterilizing smaller flasks, and pipettes and some needle-syringes I drove home, to return at midnight, and decant the serum, etc.

"By the Sunday morning train I reached Lewes. Dr. Fawssett of Lewes—he had a brother on the staff at Guy's—was waiting in a dog-cart at the station. I joined him carrying my awkward package of flasks, etc. He said nothing as I packed them in, but, when I had climbed up beside him, he looked down and said, 'You can do what you like with the boy. He will not be alive at tea time.' We drove out to the old house; a bright frosty morning. Tragedy was over the place, the servants scared and silent. The boy was very weak; breathing with difficulty; he did not seem to know me. Fawssett and I injected the serum. The syringes were small and we emptied them time and again. The Doctor left. I sat with the boy. Early in the afternoon the boy seemed to me clearly better. At 3 o'clock I sent a messenger to the Doctor to say so. Thence forward progress was uninterrupted. On Tuesday I returned to London, and sought out Ruffer. His reaction was that we must tell Lister about it. The great surgeon (not Lord Lister then) had visitors, some Continental surgeons, to dinner. 'You must tell my guests about it', he said, and insisted—so we told them in the drawing-room, at Park Crescent. The boy had a severe paralysis for a time. He grew to be 6 ft. and had a commission in the 1st world war.

"If Drury has not heard of this sequel to the first horse at 'the Brown' he may like to hear it; please give him my best remembrances. . . . Thank you so much for writing. . . ."

OBITUARIES

Prof. A. N. Whitehead, O.M., F.R.S.

ALFRED North Whitehead was born on February 15, 1861, the son of the Rev. Alfred Whitehead, at that time the headmaster of a private school in Ramsgate, and later vicar of St. Peter's, Isle of Thanet, and honorary canon of Canterbury. From Sherborne School he proceeded in 1880 to Trinity College, Cambridge, of which foundation he became a fellow in 1884 and lecturer in 1885.

As a young man, he had a place apart among Cambridge dons by reason of his interest in the outlying and comparatively unknown branches of mathematics. In the nineteenth century, this category included non-Euclidean geometry and non-commutative algebras, such as matrices and symbolic logics; and on these subjects he published in 1898 a massive and very original volume, under the title "A Treatise on Universal Algebra, with Applications".

It is interesting to observe how Whitehead's prophetic instinct led him to take up subjects which were at the time neglected and unknown to most professional mathematicians, but which have since played a great part in the interpretation of Nature. Matrix theory first came into its kingdom in 1925, when Heisenberg, Born and Jordan showed that by its aid quantum theory could be constituted as a complete logical structure. The non-Euclidean geometry of spaces of constant curvature has found its chief application in the cosmological investigations of Eddington and others from 1930 onwards, though Euclidean space had been dethroned fifteen years earlier by Einstein's theory of general relativity. The "Universal Algebra" was acclaimed on all sides as a splendid work of learning and research, and the reputation based on it led to Whitehead's election as a fellow of the Royal Society in 1903.

Of the scholars of Trinity who sat at Whitehead's feet during the last decade of the nineteenth century, there was one who became a specially attached disciple and played a great part in his subsequent life and work. This was Bertrand Russell, who entered the College in 1890 and was elected a fellow in 1895. In 1900 he and Whitehead attended an International Philosophical Congress in Paris, at which they heard an account of the work of Giuseppe Peano, who in the years immediately preceding had invented a new ideography for use in symbolic logic. They realized that Peano's symbolism was vastly superior to anything that had been known previously, and resolved to devote themselves to its development, and in particular to try to settle by its means the vexed question of the foundations of mathematics.

The thesis which they now set out to prove was that *mathematics is a part of logic*; it is, as they said, the science concerned with the logical deduction of consequences from the general premises of all reasoning; so that a separate 'philosophy of mathematics' simply does not exist. This, of course, contradicts the Kantian doctrine that mathematical proofs depend on *a priori* forms of intuition. They soon succeeded in proving that the cardinal numbers 1, 2, 3, . . . can be defined in terms of concepts which belong to pure logic, and which can be represented by Peano ideograms. From this first success they advanced to the investigations published in the three colossal volumes of "Principia Mathematica", which appeared during 1910–12 and contain altogether just under 2,000 pages.

In 1910 Whitehead resigned the Trinity lectureship and removed to London. During 1911–14 he was on the staff of University College, and from 1914 until 1924 he held a chair of mathematics in the Imperial College of Science and Technology.

There was to have been a fourth volume of the "Principia", dealing with geometry. But as Whitehead worked in preparation for it, he found himself more and more involved in questions which really belonged to epistemology and metaphysics. During 1915–17 he published several papers of a definitely philosophical character, and these were followed by two books in which he propounded a new philosophy of the external world, "An Enquiry concerning the Principles of Natural Knowledge" in 1919, and a volume of Tarner Lectures on "The Concept of Nature" in 1920. He first cleared the ground by rejecting the conceptions of Nature which then formed the accepted starting-point of physics: namely, that space and time provide, so to speak, a stage, on which ponderable bodies, æther, and electricity maintain an unending performance. In place of this, he put forward the doctrine that the ultimate components of reality are *events*. For example, a university lecture is an event: obviously it includes other events, such as the professor at his rostrum and the students at their desks; moreover, it may in its turn be regarded as a part of a larger event, such as the aggregate of all the lectures given in the same building at the same hour. This property of *extending over* other events is characteristic of events, and is the fundamental relation on which Whitehead's philosophy of the external world is based.

An event is never instantaneous; it always endures over a certain (though perhaps very short) duration of time: "the ultimate fact for observational knowledge", as he said, "is perception through a duration". The notions of an *instant* of time and a *point* of space are not truly primitive notions: to obtain them, he introduced what he called the *method of extensive abstraction*. The idea of this method is to consider a set of events each of which includes all the subsequent members of the sequence, like a nest of boxes each slightly larger than the one next inside it; if the events ultimately diminish indefinitely (or in more precise language, if no event is extended over by every event of the set) then they may be regarded as defining a limit: points of space and instants of time may be defined in this way; so that time and space are derivative concepts, they are abstractions which express relations between events.

In 1924 Whitehead resigned his chair at the Imperial College in order to accept a professorship in the Philosophical Department of Harvard University, which he occupied until his final retirement in 1937. In the session 1927–28 he returned to Britain for a time in order to deliver the Gifford Lectures in the University of Edinburgh. These, which were published in 1929 under the title "Process and Reality: an Essay in Cosmology", may be regarded as the definitive exposition of his mature philosophy, to which he gave the name 'Philosophy of Organism'. In his own words, "Speculative Philosophy is the endeavour to form a coherent, logical, necessary system of general ideas in terms of which every element of our experience can be interpreted". His point of view in this endeavour must first be made clear. He turned his back on German idealist philosophy (Kant, Fichte, Schelling, Hegel), which was concerned chiefly with mind, and had little interest in the study of Nature by the methods of mathematical and experimental science. In this sense his philosophy is, as he said, "a recurrence to pre-Kantian methods of thought". In regard to particular features, he was under obligations of one sort or another to Descartes, Leibnitz, Locke, Berkeley and Hume, and among moderns to Bradley, Bergson and Alexander; but the main roots of his doctrine were to be found in Greek philosophy, and it bore a relation to modern science which may be compared with that which Platonism bore to the Pythagorean mathematical concept of the intelligible element in Nature.

The philosophy of Whitehead is in the first place a cosmology. Now one famous philosophical cosmology has come down to us from the ancient world, namely, that set forth in the "Timæus" of Plato; and the resemblances between it and Whitehead are so striking that "Process and Reality" may be described, in a first rough approximation, as the "Timæus" brought up to date. The fundamental idea in both is the gradual evolution of order out of a primeval chaos, by a process of divine achievement. The *demiourgos* of the "Timæus" corresponds to Whitehead's God, and the Platonic 'Ideas' or 'Forms' correspond to Whitehead's 'eternal objects', which have a potentiality of 'ingression' into the becoming of actual entities, just as the 'Forms' have participation (*methexis*) in visible things. The primitive plastic substratum in which copies of the 'Forms' are made (*chora*) corresponds to Whitehead's concept of 'creativity'.

"Process and Reality" is not an easy book to read, chiefly because of the multitude of new words, and new senses of old words, with which it teems. Only time can show how many of these will be retained as a permanent enrichment of the philosophical vocabulary.

Whitehead died at Cambridge, Mass., on December 30, 1947.

EDMUND T. WHITTAKER

ON November 12, 1947, it came my way to spend, alone, a couple of hours in the evening with the late Prof. Whitehead, and Mrs. Whitehead, in their apartment within a stone's throw of the centre of Harvard. It seems likely, therefore, that I was the last person from Britain to see the great man before he died.

We talked of Trinity ("Such a good place", he whispered) and its 'characters', of whom he spoke affectionately, coupled with an occasional sly dig, as entrancing as it was kindly. He was devoted to the country of his adoption: a remark stands out in my memory—"The Americans have a streak of tenderness, yes, how valuable that is these days". Many people have used gracious words about our trans-Atlantic cousins, but it was left to him to state, quite simply and naturally, their noblest trait, and the one holding out hope for the world.

In appearance, Whitehead had become almost 'other-worldly' (something which others besides myself had noticed), as if, for him, the veil was wearing very thin. Yet there he sat, erect in his big arm-chair, full of life and interest in other people. I thought he might be getting tired, and rose to go. He, rather slowly, grasped my hand and held it, saying "Come again". But that was not to be.

F. IAN G. RAWLINS

Prof. J. N. Brønsted

PROF. JOHANNES NICOLAUS BRØNSTED died in Copenhagen on December 17, 1947, after holding the University chair of physical chemistry for nearly forty years. He was born in 1879 and spent his childhood in Jutland, where his father was employed as an engineer in connexion with land reclamation. Both his parents died while he was still a boy, and after going to school in Aarhus and Copenhagen, he began training as an engineer at the Polytechnic Institute in Copenhagen in 1898. However, it soon became clear that his interests were in chemistry, and he took the *Magister* degree in this subject in 1902, being appointed as assistant at the University Chemical Laboratory in 1905. He very soon became engrossed in the application of thermodynamics to physico-chemical problems, a subject which was to prove a central theme in all his subsequent work. A long series of papers in the years 1906–21 dealt with the theory and measurement of affinity changes, and it was the third of this series (dealing with binary mixtures) which was presented for his doctorate degree in 1908. In 1909 he was appointed (after close competition with Niels Bjerrum) to the newly instituted chair of physical chemistry, and was also made director of the physical chemistry laboratory of the Polytechnic Institute, where a great deal of his later work was carried out.

Some of Brønsted's work on affinity had dealt with electrolyte solutions, and in the period 1918–24 these became a special focus of interest. In particular he carried out an extensive series of solubility measurements, and was able to establish several simple and important general laws. When the theory of Debye and Hückel was published in 1923, it was satisfactory to find that its predictions agreed essentially with the relations already established by Brønsted, and the solubility measurements of Brønsted and LaMer (1924) still constitute some of the best evidence for the Debye–Hückel theory.

At about the same time Brønsted became interested in the kinetics of reactions in electrolyte solutions, and our present understanding of kinetic salt effects rests largely on his papers of 1920–24, which clarified a confused subject in a remarkable manner. This work directed his attention to acids and bases, and it is in this connexion that his name is most widely known to-day. The modern definition of acids and bases (proposed simultaneously in 1923 by Brønsted and by T. M. Lowry) has had a great clarifying influence in many branches of chemistry. In particular, it led to the idea of general acid-base catalysis, and although this idea had been previously suggested by H. M. Dawson and others, it was most clearly presented and justified in a series of papers by Brønsted and his colleagues on the decomposition of nitramide, the mutarotation of glucose, and various hydrolytic reactions.

In 1930 Brønsted moved to the new Physico-chemical Institute, where he enjoyed much better experimental facilities and a charming official residence. Here he continued work on reaction kinetics, especially in non-aqueous solvents, but also returned to thermodynamic problems. These latter included studies of the effect of molecular size on the thermodynamic properties of hydrocarbons, polymers and colloids. He also published several papers on the fundamental basis and formulation of the laws of thermodynamics, a subject which occupied his attention increasingly right up to his death.

Brønsted's fame to-day probably rests largely on his work on reaction kinetics and his definition of acids and bases, and it is perhaps not always realized how much he contributed to the fundamental thermodynamics of solutions. This firm foundation in thermodynamics left its mark on all his work, where an exact and elegant formulation of experimental conclusions was often coupled with a reluctance to speculate in terms of molecular models. Although he contributed little to the elaboration of practical techniques, his experimental work showed great skill in the choice of methods and of systems for investigation. He preferred to work independently of others, and the only notable example of collaboration outside his own field is his well-known work with G. von Hevesy on the separation of the isotopes of mercury. He did not suffer fools gladly among his research students; but it was a great inspiration to work under his guidance, and many foreign visitors enjoyed the hospitality of his laboratory from 1920 onwards. Brønsted himself travelled widely in Europe and paid one visit to the United States as a visiting professor at Yale. He received many honours from learned bodies abroad, such as the American Academy of Arts and Sciences, the Chemical Society of London, and also from the University of London.

Brønsted was a man of great personal charm and took a keen interest in the art, literature and natural history of several countries besides his own. During most of his life he played little part in public affairs, but the German occupation of Denmark led him to think more deeply on national and international questions, and in 1947 he became a member of parliament, though his last illness prevented him from taking his seat. He was one of the small band of great men of science who have given Denmark a scientific reputation quite out of proportion to her size, and he will be mourned by friends and colleagues in many parts of the world. R. P. BELL

Mr. Orville Wright

THE death on January 30 of Orville Wright marks the passing of the second of the great co-pioneers of mechanical flight (Wilbur Wright died in 1912), and of the man who actually made the first controlled and sustained flight in an aeroplane. Orville was born at Dayton, Ohio, on August 19, 1871, and was the fourth son of Bishop Milton Wright, Wilbur being the third. The two brothers grew up inseparable in youth and manhood; so close was their collaboration that their experimental work can be regarded only as a single achievement—though Wilbur, on account of his age and special gifts, may have been the leader.

In contrast to some other investigators, the Wright brothers approached the problem of flight by the method known to have been employed in Nature many millions of years ago, namely, through the evolutionary process of gliding, which they saw to be obligatory. Their contribution was, essentially, the devising of a complete system of control where none had previously existed; the design of effective cambered wings, determined by wind-tunnel research; the development of airscrews and the adaptation of a petrol engine; and, finally, the incorporation of all these devices in a practical machine.

The unique distinction of being the first man to fly in the true sense—which fell to Orville at Kitty Hawk, North Carolina, on December 17, 1903—was borne by him with dignity and charm. After

the untimely death of his brother Wilbur, he took a less active part in aeronautics, though his interest never waned. More recently, he was concerned with establishing the credit properly due to them for their historic achievement, and in 1928 he sent the original biplane of 1903 to the Science Museum in London in order to receive that unqualified recognition which he feared was not forthcoming in some quarters of his own country. The machine is still on exhibition there.

M. J. B. Davy

We regret to announce the following deaths:

Dr. Bernard Dyer, well-known agricultural chemist and public analyst, formerly president of the Society of Public Analysts and Other Analytical Chemists, on February 12, aged ninety-one.

Prof. R. B. Thomson, emeritus professor of botany, University of Toronto, well known for his work on plant anatomy and morphology, on July 31, 1947, aged seventy-six.

NEWS and VIEWS

Dr. S. E. Sheppard

Dr. S. E. Sheppard, well known throughout the photographic industry, retired on January 1, 1948, after thirty-five years with the Eastman Kodak Research Laboratories, Rochester, U.S.A. Dr. Sheppard graduated at University College, London, where he later obtained the degree of doctor of science, submitting a thesis on the formation of the latent photographic image and the chemistry of development. The work was done jointly with Dr. C. E. K. Mees, now a vice-president of the Eastman Kodak Company, and was published as "Investigations on the Theory of the Photographic Process", so well known by photographic research workers. In 1913 the Eastman Kodak Research Laboratories were newly organised and Dr. Sheppard went to the United States to join the staff as a chemist, and since then he has made valuable contributions in many fields of photographic research. Perhaps his best-known work relates to the function of gelatin in photographic emulsions. He and his co-workers found that the sensitizing action of gelatin is influenced by the presence of certain sulphur compounds, among the most important of which are derivatives of mustard oil. This work has led to the comment among those familiar with photography that if the cow had not a taste for mustard we should have no fast photographic emulsions. Dr. Sheppard made a special study of colloid chemistry which, apart from its obvious influence on his work on gelatin, led to such unrelated work as the development of a colloidal fuel for use in submarines during the First World War and investigations into the properties of cellulose and rubber. He has published some two hundred and fifty scientific papers and written several books; the value of his contributions to photographic science has been recognized by honours conferred upon him by photographic and chemical societies on both sides of the Atlantic.

Harrison Memorial Prize: Dr. D. H. R. Barton

The Harrison Memorial Prize for 1947 has been awarded to Dr. D. H. R. Barton. Dr. Barton studied at the Imperial College of Science and Technology, London, where he graduated in 1940 with first-class honours, being awarded the Hofmann Prize for special distinction in organic chemistry; he is now an I.C.I. Research Fellow in the Department of Inorganic and Physical Chemistry at the Imperial College. The Harrison Memorial Prize is awarded by a committee, consisting of the presidents of the Chemical Society, the Royal Institute of Chemistry, the Society of Chemical Industry and the Pharmaceutical Society, to a British chemist less than thirty years of age for original chemical investigations during the previous five years.

British Museum (Natural History)

The Principal Trustees of the British Museum have appointed Mr. David Dilwyn John and Dr. Francis Charles Fraser to be deputy keepers in the Department of Zoology of the British Museum (Natural History). Mr. John, who is forty-six, has been in charge of Recent echinoderms at the Museum since he joined the staff in 1935. He studied zoology in the University of Wales and served during 1925–35 on the scientific staff of the "Discovery" Investigations, during which period he took part in three commissions in Antarctic waters. On the third of them, while he was scientific officer in charge, the Antarctic continent was circumnavigated, chiefly in the winter months. He has been awarded the Polar Medal. During the War he served in the Royal Artillery. Dr. Fraser is forty-four years of age, and served with "Discovery" Investigations during 1925–33, and has received the Polar Medal for three periods of service in the Antarctic. He joined the Museum staff in 1933, since when he has been in charge of the osteological collections, and has made a special study of whales.

British Institute of Archæology in Ankara

The British Institute of Archæology in Ankara was formally inaugurated on January 15 by H.E. Resat Semsettin Sirer, Turkish Minister of National Education and H.E. the British Ambassador, Sir David Kelly, in temporary quarters at 8 Istiklâl Caddesi, Ankara. Members of the Turkish Council of Ministers and the Diplomatic Corps were present, and were received by Prof. John Garstang, director of the Institute, and Mrs. Garstang. The Institute is a newly founded body, designed to carry out work similar to that of the other British Schools of Archæology at Athens, Rome, Jerusalem and Baghdad. It will form a centre of research to which British students of archæology and kindred subjects such as anthropology and ethnology will go to carry out their work. For this purpose the Institute is bringing together a library and collections of archæological objects, photographs and squeezes of inscriptions in so far as these are necessary to supplement the collections in Turkish museums. It is offering this year a scholarship of £300 to a student wishing to carry out researches in Turkey in some aspect of Anatolian archæology. It is also hoped to offer such a scholarship annually and a fellowship of £350 to an advanced student.

As a contribution to research in the archæology of Turkey and as a valuable means of training students, the Institute will undertake, as soon as funds are forthcoming, a programme of excavation of sites in Turkey and of archæological exploration on the surface. It will also give all assistance possible

to approved British expeditions for excavation or other research. For the information of would-be students, the following rough estimate of expenses may be useful: living in Turkey, average £T5 per day for 100 days (say, £50); travelling from Britain and back £120; incidental expenses during stay £30; balance for travel and expenses of research in Turkey £100 (total £300). The Institute is organised under a committee in London, on which there are representatives of the British Academy, the British Museum, the London Institute of Archæology, the British School at Athens, the Society for Hellenic Studies, the School of Oriental Studies, the Royal Society, the Society of Antiquaries, the Royal Asiatic Society, the Royal Anthropological Institute, as well as official representatives of the Universities of Oxford, Cambridge, London and Edinburgh. The committee's honorary secretary in London is Miss K. Kenyon, c/o Institute of Archæology, Inner Circle, Regent's Park, London, N.W.1.

Transit Circle for the Royal Observatory, Greenwich

When the Royal Observatory moves from Greenwich to Herstmonceux, the Airy transit circle, which was installed in 1851 and which marks the zero meridian of longitude, will be left at Greenwich, along with a collection of older instruments dating back to the time of Halley. They will form an interesting historical exhibit. The Airy instrument has reached the end of its useful life; the objective has twice been repolished and refigured and is too thin for a further repolishing which is now needed; many of the circle graduations have been almost obliterated by repeated cleaning; the instrument is non-reversible and obsolete in various respects. The Observatory possesses a modern reversible 7-in. transit circle, made by Cooke, Troughton and Simms, and installed in 1936, which is required primarily for fundamental observations. A second transit circle is needed for differential zone observations.

When the Astronomer Royal, Sir Harold Spencer Jones, was in Australia last year, he visited the Melbourne Observatory, which was recently closed. Much of its work has been taken over by the Commonwealth Observatory at Mount Stromlo near Canberra. There he saw an 8-in. reversible transit circle, of 12-ft. focal length, with two circles of 3-ft. diameter. It was made by Troughton and Simms, and installed in 1884; an impersonal micrometer has since been provided for it. The instrument had been used with care and was in excellent condition. When the Government of Victoria was made aware of the requirement for such an instrument by the Royal Observatory, it generously decided to present the telescope. The instrument was dismantled and packed with the assistance of the Royal Australian Navy, and has recently arrived at Greenwich. It will be installed at Herstmonceux in due course.

The Biometric Society: British Region

The Biometric Society, a new international organisation the aim of which is the furtherance of quantitative biology in all its aspects, came into being at a conference held in Woods Hole, Massachusetts, during September 1947. Its president is Prof. R. A. Fisher, and its secretary, Dr. C. I. Bliss, of New Haven, Connecticut. It is hoped to hold international meetings every few years, and all members will receive the journal *Biometrics*. For the purpose of more local activities, the Society is organised into regions, of which it is proposed that a British Region shall form one. A provisional committee, under the chairmanship of Dr. J. W. Trevan, vice-president for the Region, is now engaged in drafting proposals for the regional organisation and activities, which it is intended will primarily provide a means of bringing together all those biologists and biochemists who are interested in the application of quantitative methods, with the statisticians and mathematicians who can co-operate in developing these methods. It is hoped shortly to present these proposals to an inaugural meeting of the Region. Further information can be obtained from the Regional Secretary, Dr. K. Mather, of the John Innes Horticultural Institution, London, S.W.19.

Breeding of Avocets in Britain

Prior to 1938, when two pairs of avocets were reported to have nested in Ireland, ornithological records contained no reference to the breeding of these birds in Britain for more than a century. During the summer of 1947, however, two small colonies of avocets (*Recurvirostra avosetta*) established themselves in East Anglia. According to P. E. Brown and E. Lynn-Allen (*British Birds*, **41**, No. 1, January 1948), nine pairs of adult birds, of which at least seven pairs nested, were present during the breeding season. Altogether sixteen young birds were known to have reached the free-flying state. The Royal Society for the Protection of Birds has already taken measures to ensure that the birds will be adequately safeguarded should they return in 1948.

School Ecological Studies: Blundell's Scientific Publication

The second number (1947) of the *Magazine of the Blundell's School Science Society* is, like the first, worthy of special note since it has carefully avoided the usual mistake of becoming a rather extravagant, even useless, potpourri of miscellaneous information and has again developed a theme—that of ecology. In fact, it is a good though elementary collection of articles mainly of ecological interest. In an article on "Butterflies of the Tiverton Area", M. A. Lyne describes twenty-seven species found within a ten-mile radius of Blundell's School. P. R. Freeth's interest lies mainly in bird watching and bird ringing, and records that the British Birds Marking Scheme was revived at the School in 1947 after a lapse of eight years. Thirty-nine birds were ringed. O. H. D. Portsmouth describes the flora of a local marsh meadow. The marsh is divided into a wet area dominated by *Carex panicea* and a drier area dominated by *Juncus communis*. This article gives the floral ecology in detail and reveals an extraordinarily sound grasp of the principles of ecological study by such a young author.

R. Honey reports on a survey of the marine algæ of Guernsey, giving a systematic list and dealing with ecological factors, distribution and relations between flora and habitat. G. O. Mackie confines himself to a more intensive ecological study of the flora and fauna of rain gutters. Other articles, all ecological in approach, are the animal ecology of a field drainage scheme by J. S. Miller, some factors affecting the distribution of the may-fly by R. H. Champion, fauna of a stream by E. W. Sturton, and observations in bird territory by J. A. Shepherd. The entire publication reveals a sound biological training, indicates that the young students are stimulated to a healthy enthusiasm (they are fortunate in that their

school is situated in a biologist's paradise), and offers its contributors a rare opportunity for training in setting out their observations, results and conclusions concisely and accurately.

Quarterly Journal of Experimental Psychology

THE Experimental Psychology Group, a small private society the membership of which is drawn from the teaching and research staffs of British universities and research institutions, and the object of which is to further the experimental and scientific study of psychological problems, has decided to found a new journal, to be known as the *Quarterly Journal of Experimental Psychology*. While the volume of scientific work within the general field of psychology and the neighbouring fringes of physiology, medicine, biology and physics has greatly increased within the past few years, publication has been severely restricted by lack of a journal devoted exclusively to these fields. Much work has appeared in journals representing other branches of science. The intention is to produce a small journal of high quality in which scientific psychological work, whether experimental or clinical, and whether carried out in psychological or in other research institutions, may find a focus and an outlet. The journal will be edited by R. C. Oldfield, of the Institute of Experimental Psychology, University of Oxford, who will be assisted by an editorial board of six other members of the Experimental Psychology Group, and it will be published by Messrs. W. Heffer and Sons, Ltd., Cambridge (subscription, 30*s*. a volume of four parts). It is hoped to produce the first part in March.

Submarine Gravity Survey in the English Channel

THE Department of Geodesy and Geophysics, University of Cambridge, is to make a gravity survey on board H.M. Submarine *Talent* in the English Channel during May. The project is being carried out under the auspices of the Royal Society with the full co-operation of the Royal Navy. The object of the expedition is to obtain information about the structure of the channel basin which should help in interpreting the relation of the geology of southern England to that of the Continent. The cruise will last for four weeks and cover the area between England and France from Plymouth to Hastings. H.M. Submarine *Talent* will be manned by her normal complement of officers and men of the Royal Navy, but three civilian scientific workers, Mr. B. C. Browne, Mr. R. I. B. Cooper and Mr. R. L. G. Gilbert, will also be on board. She will be equipped with special apparatus, some of which has generously been lent by the Danish Geodetic Commission. Accurate measurement of this kind can only be made under very steady conditions, such as those found by a submarine at a depth of 100–200 ft. This method of working was originally devised by the Dutch geophysicist, Prof. F. A. Vening-Meinesz, and has been widely used by him. Similar work has also been carried out by the United States, France, Italy, the U.S.S.R., Japan, and Britain. A British expedition in August 1946 on board H.M.S. *Tudor* surveyed an area from the north coast of Spain to the Rockall Bank. Besides valuable scientific results, the experience gained showed how the apparatus and technique might be improved.

The Berlin Herbarium

MR. A. H. G. ALSTON, of the British Museum (Natural History), writes: "I have received the following information from a correspondent in Germany: The portion of the herbarium, which was evacuated from Berlin to Bleicherode, has quite recently been handed over officially to the Berlin University, and deposited in the Russian sector of Berlin. It was generally believed in Germany that these collections had been transported to the U.S.S.R., but, in fact, they remained at Erfurt until 'the President of the Moscow Academy of Science decided not to take over German *Kulturgut*'."

Ramsay Memorial Fellowships for Chemical Research

THE trustees will consider in June applications for Ramsay Memorial Fellowships for chemical research, one of which will be limited to candidates educated in Glasgow. The value of each Fellowship will be £400 per annum, to which may be added a grant for expenses of research not exceeding £100 per annum, and it will normally be tenable for two years. Full particulars can be obtained from the Joint Honorary Secretaries, Ramsay Memorial Fellowships Trust, University College London, Gower Street, W.C.1, to whom applications must be forwarded not later than April 17.

Announcements

THE Linnean Society of London has awarded the Linnean Medal for the year 1948 to Dr. Agnes Arber, F.R.S., of Cambridge. The Medal will be presented at the anniversary meeting on May 24.

THE Council of the University of Bristol has made the following appointments in the Department of Physics, to take effect on the retirement of Prof. A. M. Tyndall at the end of the present session: Prof. N. F. Mott, to be Henry Overton Wills professor of physics and director of the Wills Laboratory; Dr. C. F. Powell, to be Melville Wills professor of physics; Dr. S. H. Piper, to be assistant director of the Wills Laboratory.

THE following elections to the Paris Academy of Sciences have been announced: André Boivin, *correspondant* for the Section of Rural Economy, in succession to the late M. Henri Vallée; and Dr. Theodor Mortensen, director of the Department of Invertebrates, Zoological Museum, Copenhagen, *correspondant* for the Section of Anatomy and Zoology, in succession to the late M. Edouard Chatton.

DR. E. W. FELL has been appointed senior assistant in metallurgy at the Bradford Technical College. He was educated at Haileybury and the Universities of Birmingham, Aachen and Cambridge, and has many years of varied experience in the practice of metallurgy.

AT the annual meeting of the Manchester Joint Research Council held on February 16, Sir Raymond Streat was elected chairman and Sir Charles Renold honorary treasurer.

THE Association of British Science Writers is now open to accept associate members. Associate membership is intended for non-professional science writers, that is, those who do not earn the major part of their income from science writing. Those interested should apply for particulars to the honorary secretary, Mr. Maurice Goldsmith, at 81 Hillside Gardens, Edgware, Middlesex.

SIR JOHN MYRES writes, referring to his review of "A Glossary of Greek Fishes" (*Nature*, Feb. 7, p. 185), "the words *weel* and *péganon*, which I queried as misprints, are both correct".

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Animal Tissue Cells in Protein-Free Media

FEW attempts have been made to maintain (or grow) animal tissue cells in protein-free media, although it has been shown[1] that the low molecular weight substances of blood plasma are of the utmost importance for the life of tissue cells, which rapidly perish in dialysed blood plasma. It has further been possible[1,2], by the addition of a number of amino-acids together with glutamine, glutathione and hexose diphosphate to a medium containing only dialysed plasma proteins and dialysed embryonic extract, to obtain survival and growth of the cells. The few attempts made to devise completely synthetic media have met with only partial success because of lack of a suitable technique, and because very little is really known about the fundamental nutritional requirements of animal tissue cells during survival and growth.

M. R. Lewis and W. H. Lewis[3] obtained migration and growth of cells in hanging-drop cultures in media containing inorganic salts, dextrose or maltose, amino-acids and polypeptides. As they also obtained migration and growth in a medium containing inorganic salts only, there could, however, be no doubt that their results were complicated by insufficiently defined residual growth phenomena originating from the use of rather large tissue explants and small volumes of media. P. R. White[4] has recently, by means of a modified roller tube technique, obtained migration and growth of long duration in a synthetic medium containing a large number of substances supposed to be of importance for the maintenance and growth of animal tissue cells *in vitro*. The manner in which White prepared the tissue explants and placed them in the cultivation tubes does not seem to ensure, however, that the reaction of the cells was due solely to the constituents of the synthetic medium (cf. also ref. 2).

In order to be able to study the effects of some protein-free media, I have made use of hanging-drop cultures made according to the technique of Lewis and Lewis[3]. By the use of very small explants (of embryonic heart tissue; 8–9 day embryos) it apparently became possible to avoid contamination of the media by substances given off from the explants. The following results were obtained:

(1) In Tyrode solution no migration of cells was obtained, undoubtedly because a solution containing only inorganic salts and dextrose cannot maintain the life of animal tissue cells.

(2) Tyrode solution containing the following nine amino-acids was made up: *d*-lysine dihydrochloride (0·006 per cent); *d*-arginine (0·003 per cent); *l*-tryptophane (0·002 per cent); *d,l*-methionine (0·001 per cent); *l*-histidine monohydrochloride (0·001 per cent); glutamic acid (0·006 per cent); *l*-aspartic acid (0·002 per cent); *l*-proline (0·002 per cent); *l*-cystine (0·0006 per cent), (cf. ref. 1). Zones of migrating cells were formed around the explants. The number of migrated cells showed great variation (from a few hundred to about 1,500 cells). The mitotic frequency was very low (about 1 per 4,000 cells). The cells survived two or three days, looking apparently normal. The addition of glutamine (0·05 per cent), glutathione (0·01 per cent) and hexose diphosphate (0·03 per cent) did not change the result.

(3) Dialysate obtained by dialysis of blood plasma (adult cock) against an equal volume of Ringer's solution (0·1 per cent dextrose). Large zones of migrating cells were observed (the number of migrating cells varying between a few hundred and more than 2,000). The mitotic frequency was very low (1 per 2,500). Dialysates of pig and ox serum have so far given no cellular migration.

A number of experiments have also been made, placing the tissue explants at the bottom of Carrel flasks (volume of medium 0·5–1 c.c., one explant in each flask). The *p*H was adjusted to 7·6–7·8 by regulation of the amount of carbon dioxide present. The large volume of the medium, and frequent renewals, made it possible to keep its composition constant—this is scarcely possible in hanging-drop cultures for any long period of time.

In this way, survival of zones of migrated cells in the amino-acid mixture (in Tyrode solution) or in plasma dialysate up to ten to twelve days was achieved; no migration of cells could be obtained in Tyrode solution alone. It is, moreover, possible to isolate zones of migrated cells placed at the bottom of Carrel flasks, the original explants being removed after one or two days.

Using the procedures described here makes it possible to study the effects of protein-free media on tissue cells *in vitro*.

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Failure of Sulphanilamide to Inhibit Calcification of Bone

BENESCH and co-workers[1] have reported almost complete absence of calcification in the bones of rat fœtuses at term, following administration of large doses of sulphanilamide and sulphapyridine to the mothers during the last seven to ten days of the gestation period. Their report was based upon hæmatoxylin-staining of decalcified bones, with the reservation that this method might not be reliable, and upon X-ray examination of the bones of the fœtuses from sulphonamide-treated rats, no mention being made of control observations upon normal fœtuses. The results of observations upon mice were stated to be equivocal.

We have administered sulphanilamide to pregnant rats under conditions similar to those reported by Benesch *et al.*, and have observed the new-born rats from both treated and untreated mothers by positive staining of bone salt in undecalcified bones and by X-rays. Our observations do not confirm those of Benesch *et al.*

Four pregnant rats received 720 mgm. of sulphanilamide/kgm./day during the latter 5, 7, 11 and 16 days, respectively, of pregnancy. Three new-born rats of each litter were examined by X-rays and autopsied within fifteen hours after birth. X-ray films were made with 10 m. amp. current and 1 sec.

exposure; the technique of development was identical for all. Undecalcified histological preparations stained by the von Kóssa method, as described by McLean and Bloom[3], were made from sagittal sections through the knee joint. Litters from five normal untreated rats were similarly examined and served as controls.

The findings in all these animals were comparable to those described by Bloom and Bloom[3] in embryonic and new-born rats, and we have been unable to detect any differences between rats born from treated and untreated mothers. It is true that there are "striking defects in various parts of the skeleton" of new-born rats, as shown by X-ray examination; but these defects are not peculiar to the offspring from mothers treated with sulphonamides.

Benesch *et al.* began their work with the hypothesis that sulphanilamide, which inhibits carbonic anhydrase, might interfere with calcification, with the expectation that sulphapyridine, which does not have any effect on this enzyme, would have no effect on the deposition of bone salt. In view of their reported findings, which appeared to indicate that both sulphonamides inhibited calcification, they offered the interpretation that this effect was due to inhibition of the activity of bone phosphatase. Silver and Golding[4] have shown that bone phosphatase is inhibited by sulphonamides *in vitro*, but the concentrations required (250–1,500 mgm. per cent) and the degree of inhibition (50 per cent or less) would make it extremely unlikely that this mechanism could have physiological significance.

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Bilirubin-Serum Protein Complexes and the van den Bergh Reaction

RECENT work by N. H. Martin[1], showing complex formation between bilirubin and the α-globulin as well as the albumin components of plasma, is not only of great theoretical and practical significance from the point of view of the physical chemistry of the proteins, but also may have important implications regarding the interpretation of the van den Bergh reaction. The binding of bilirubin to different plasma protein fractions might be related to the alleged two forms of bilirubin postulated by many workers to explain the different types of direct van den Bergh reaction.

We have examined a small number of jaundiced sera by the electrophoresis technique and can confirm Martin's findings that a small but definite fraction of the bilirubin migrates with the α-globulin fraction, in addition to the migration of the main fraction of the bilirubin with the albumin. In all cases, bilirubin migrated in much the same proportions with the albumin and α-globulin fractions respectively, whatever the nature of the jaundice or the type of direct van den Bergh reaction. One of the jaundiced sera we examined was obtained from a patient with retention jaundice and contained 16·2 mgm. bilirubin per 100 ml., gave an almost completely negative direct van den Bergh reaction and a direct–indirect quotient (*D.I.Q.*)[2] of 9 by the 30 min. Malloy and Evelyn method. The bilirubin of this serum behaved in the electrophoresis apparatus in precisely the same way as bilirubin of sera from patients with obstructive jaundice or acute hepatitis and containing similar amounts of bilirubin but giving typical positive direct van den Bergh reactions and *D.I.Q.* values greater than 50. We are therefore compelled to conclude that the binding of bilirubin by different fractions of the plasma proteins bears no direct relationship to the nature of the direct van den Bergh reaction.

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Alkaline Phosphatase in Fish Gut

SINCE Gomori[1] and Takamatsu[2] adopted a histochemical test for the demonstration of alkaline phosphatase, many investigators have examined the distribution of the enzyme in animal tissues; the majority, however, employed material from mammals.

I have recently been studying the distribution of the enzyme in the alimentary tract of certain freshwater fishes, namely, three species of the family Cyprinidæ. The results are not without interest. For example, the concentration of the enzyme varies from species to species as well as in the various segments of the otherwise comparatively uniform intestine. The sites of activity of the enzyme are the free border of the absorptive cells, and the granular cells which are found in the submucosa and which invade the intestinal epithelium (these are known to be derived from granulocyte leucocytes, Duthie[3]). The enzyme occurs also in the connective tissue, blood vessels, and in the stratified epithelium lining the buccal and pharyngeal cavities. The presence of the enzyme in the Golgi zone of the absorptive cells is not a constant feature of these fish, contrary to what Emmel[4], and Deane and Dempsey[5] have found in certain mammals.

It is generally accepted that the enzyme is involved in a phosphorylation process of glucose[6,7]. Its presence in the stratified epithelium, especially concentrated in the stratum germinativum, is therefore of interest; and it is suggested that in such epithelium, where the intercellular substance is very scanty, glucose may pass into the epithelium by a chemical process of phosphorylation, initiated by the enzyme secreted at its base, rather than by diffusion.

Gomori and Takamatsu incubated the sections with the substrate at 37° C., which corresponds roughly to the body temperature in mammals. In a few experiments, incubation has been carried out at 28° C. with fish material, and very good results were obtained; the optimum temperature for the enzyme in cold-blooded vertebrates is not necessarily the

same as in mammals. This, and also the optimum *p*H, needs further investigation.

In view of these facts, and that our knowledge of the comparative histochemistry of the lower vertebrates is slight, a comparative study of the distribution of alkaline phosphatase in the alimentary tract of lower vertebrates, and an experimental investigation of the conditions under which the enzyme acts in these animals, are needed, and seem likely to yield results of considerable interest in the histochemical field. The work is now proceeding, and it is hoped to publish a full account in the near future.

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Behaviour of Gorini's Acid-Proteolytic Lactic Cocci with Penicillin

The study of penicillin resistance is interesting particularly if observations are made on the usual substratum of the bacteria, that is, in the optimum conditions of life. Basing my work on the observation of C. Gorini[1] that the colonies of his cocci inoculated in agar broth with milk form around each colony a transparent zone due to proteolysis that has dissolved the casein, I carried out tests by the following method: the Petri plates, containing 15 ml. of melted agar broth flooded with 20 per cent of milk, were inoculated with 1 ml. of a 48-hour milk-culture of the stock in question. Holes were made on the slides, as is done in routine testing of penicillin, and in each was put a drop of serial dilutions of crystallized sodium penicillin *C.S.C.* The method proved simple, quick and very sensitive. The zones of inhibition showed themselves as cloudy circles where the casein had not been proteolysed, whereas the rest of the plate became clear, the vitality of the bacteria there being shown by their proteolytic power.

Comparing the diameter of the circles observed with the acid-proteolytes and those obtained with *Staphylococcus aureus* under the same conditions (with the exception of the addition of milk), I was able to establish the following scale of sensitiveness for *E3*, *M50*, *C8*, which are three different stock-cultures of acid-proteolyte.

Staphylococcus aureus Oxford	Acid-proteolytic lactic cocci Gor.		
	E3	*M50*	*C8*
I	1/5	1/100	1/200

This method, devised for the fuller study of the properties of the acid-proteolytes, has led to the following interesting observation: around all the cloudy circles of inhibition, zones of increasing clearness are noticed in regard to the rest of the slides, which I interpret as showing greater strength of proteolytic activity of the bacteria in these places.

As the photographs show, a background zone of proteolytic activity can be seen in the plates, a circle (immediately around the drop of penicillin) of non-activity, and a larger circle (around the first) of the maximum proteolytic activity. The most plausible explanation is that a zone of different bacterial activity is being dealt with. I have seen multiple concentric circles with *Staphylococcus*, too; but in the case described above they are of a regularity and clearness that require fuller study.

The investigation shows that the sensitivity to penicillin of the Gorini acid-proteolytic lactic cocci stock examined (in conformity with their great variability as stated by C. Gorini[1]) varies between a minimum of 5 o.u. for the most sensitive and a maximum of 200 o.u. for the most resisting. Tests on the liquid of a four-day milk-centrifuged culture show very little inhibitory power on penicillin not due to penicillinase but to heat-resisting substances.

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Milan. Oct. 29.

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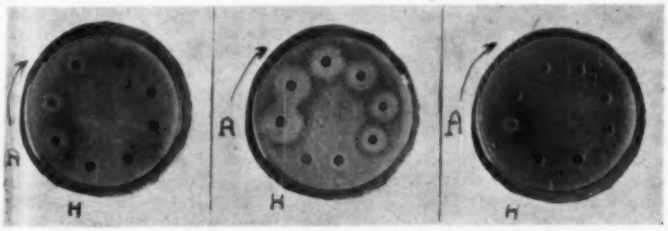
Aerobiology on Commercial Air Routes

While I was a passenger from New Zealand to the United Kingdom in September 1947, I was able to expose microscope slides on a stick held out from commercial flying boats, and I trapped as many as 143 pollen grains and 273 fungal spores on 7·5 sq. cm. of adhesive surface exposed for five minutes at 140 knots (about 160 m.p.h.). Proctor[1] outlines a number of complicated constructions for exposure of slides from aeroplanes; but the simple method I have used makes it possible for biologists travelling as ordinary passengers on commercial aircraft to contribute to our knowledge of aerobiology. The method is due to a suggestion by Mr. E. A. Madden of the Department of Scientific and Industrial Research, New Zealand, to run a leading wire before the slides to break up the pressure cone, and to streamline the stick behind in order to prevent turbulence from increasing its apparent width. At the lower speed of their aircraft, this may not have been necessary for the single slides of Polunin *et al.*[2] and of Stakman *et al.*[3]; but the larger surface of Stakman's multi-slide trap may have required some such provision, and hence its poorer performance. My exposures were made through the astro-hatch of the Empire-class flying boat *Aotearoa*, over the Tasman Sea, and through the window of the steward's pantry on the Hythe flying boat, *Hobart*, thereafter.



M50 *E3* *C8*

Behaviour of three stocks of acid-proteolytic lactic cocci Gor.
In the holes of every plate there are the following serial dilutions of penicillin: o.u./ml.: from *A* to *H*, 100, 25, 10, 2, 1, 0·4, 0·2, 0

Using nutrient agar (a potato-dextrose agar with addition of protein, etc., used in and supplied by the Laboratory of the Wellington (N.Z.) Public Hospital; commonly used for *Brucellus abortus*, and recommended for a wide range of organisms) on the slides, and establishing controls over every phase of the operation, I have obtained very few colonies growing: a different strain of *Cladosporium herbarum* Link ex Fr. (kindly identified by Mr. H. A. Dade, assistant director, Imperial Mycological Institute (letter dated Oct. 14, 1947)) over each of the Gulf of Carpentaria, the Island of Sumbawa and the Strait of Bonifacio, while 200 miles off Sydney, over the Tasman Sea, some eight colonies (of four or five different kinds) of organisms appeared (identifications are awaited from Sydney). The methods used may have missed some possible colonies, but this scarcity of viable (on that agar) organisms (six other exposures were made, but without growths) contrasts with the profusion of growths on the Petri dishes (of unstated size) exposed by Polunin *et al.*[2] in the Arctic. Their still unwrapped dishes, however, were no control whatever for the probable contamination from the arm (sleeve?) along which they slid the lid of the dish during exposures. My agar surface was about 10 sq. cm.

The chief results of my work will be from slides carrying an area of 7·5 sq. cm. of glycerine jelly, containing a little carbol fuchsin. Prepared in the way usual for allergy studies, where only large numbers are significant, these slides showed a little contamination. For studies such as the present one, where small numbers are significant, more rigorous methods of preparation should be used. The slides were stored under 'Cellophane' arranged so that successive removals left the remaining slides still protected from dust. A cover-slip was added after exposure. Out of the ten exposed slides and four controls, only the three from the Tasman Sea and one control have been examined in detail to locate the objects caught. An analysis of these slides is as follows:

Slide number and position	61, control covered at Cambridge	51, at 2,100 ft. 37° 08′ S.: 173° 40′ E. 50 miles off N.Z.	52, at 4,500 ft. 35° 58′ S.: 163° 00′ E. 700 miles off Aust.	53, at 4,000 ft. 34° 40′ S.: 155° 20′ E.† 210 miles off Aust.
Pollen grains	4	2	16	143
Fungal spores	1	3	14	273
Pieces of hypha	0	1	2	26
Other biota*	8 (+ 15)	11 (+ 17)	14 (+ 19)	47 (+ 11)
Total	28	34	65	500

* Mites', etc., eggs were reported present at time of preparation. They are represented by the figure in brackets and show no correlation w th exposure.

† The exposure was made 15 minutes later than this position.

Slide No. 51, so near land, should be regarded as showing no catch in view of the control slide, No. 61, the pollen grains on both being likely contaminants from the laboratory where the slides were prepared. On the meagre information available, Dr. R. G. Simmers, acting director of the Meteorological Service, New Zealand, suggests (letter dated Oct. 22, 1947) that the wind of direction 200° at the position of the slide had "likely" crossed New Zealand from south-east to north-west (that is, at a direction of 135°). Harmonizing these two directions would bring the "crossing" in the neighbourhood of the Cook Strait region. If this were so, it would explain the absence of particles here, a contrast with Erdtman's[4] near-land experience on a North Atlantic steamer crossing.

Slides Nos. 52 and 53 represent 75 and 875 pollen grains, respectively, and 70 and 1,680 fungal spores, respectively, per 100 c. metres of air, assuming that the volume of space traversed represents the volume of air 'swept'. This is a great contrast with Erdtman's[4] 0·7–18·0 (pollen and fern spores) for his North Atlantic crossing in May–June, 1937.

The routes of the air masses to which these two slides were exposed have also been indicated by Dr. Simmers. For No. 53 the air crossed the coast of Australia about 100 miles south of Sydney. For No. 52 it possibly crossed southern Victoria or even came through Bass Strait. The pollen of *Callitris* sp. was represented by 84 grains on No. 53 and 5 grains on No. 52. The flowering times and distribution of *Callitris* species, according to Ewart[5], would satisfy the route for air met by No. 53, but would require for the air of No. 52 a more direct route over southern New South Wales or a curved route from north-west Victoria or South Australia. The first route would give transport of 900 miles approximately (200 over land, 700 over sea) from southern New South Wales. The second route would give transport of about 1,200 miles, at least, from north-west Victoria. The lesser distance is distinctly greater than the 500–700 miles, depending on interpretation of wind, given by Meier[6] for living spores over the Caribbean Sea.

Other interesting objects observed were numerous spores of *Cladosporium herbarum*, many multicellular conidia of Fungi Imperfecti, about twelve rust (Uredinales) spores on No. 53, and hyphæ probably of sooty mould fungi. It should be noted that even for slide 52 the particles still had 4,500 feet to fall.

These incomplete data and simple methods are brought forward to encourage others to follow suit if opportunity arises in the form of an aeroplane journey. It is interesting also to note the possibility of employing pollen studies for elucidating paths of air masses in areas deficient in meteorological recordings, such as the Tasman Sea region.

I am indebted to the airway companies concerned and the crews of the aircrafts for their generous co-operation, and to friends who helped in the preparations. Full acknowledgment will be made in the detailed account being prepared.

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Jan. 26.

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An Undescribed Structure in the Rodent Rhinarium

During a survey of the detailed sculpturing of the specialized naked integument of the mammalian rhinarium, what appears to be a hitherto undescribed tactile organ has been noted in almost all members of the Rodentia examined, except the Hystricomorpha. Developed in incipient form in the Lagomorpha, it becomes more defined in the Sciuromorpha, but attains its highest differentiation in the Myomorpha.

In most rodents the naked rhinarium is comparatively restricted and frequently partially or completely overshadowed by folds from neighbouring hair-clad parts of the muzzle. But the internarial septum and the immediate margins of the nares are generally free from hairs or at least glabrous. At the medial angle of the narial opening is a more or less raised area of rounded or oval outline. Relatively little raised in *Lepus* and *Oryctolagus*, it becomes more prominent in Sciuromorpha and Myomorpha, encroaching upon the internarial region sometimes to the extent of being separated from its fellow merely by a median vertical sulcus.

The surface of the above-mentioned elevation is variously sculptured in different species. In *Sciurus* it is merely papillated. In the Lagomorpha the anterior two thirds is finely papillated, the papillæ being arranged in longitudinal rows, but on the posterior third the papillæ appear to have fused to form a series (five to six) of longitudinal ridges closely simulating the papillary ridges of the Primate cheiridium. In the Myomorpha the whole surface is definitely ridged in the same manner as the Primate hand, the pattern being generally a simple one. In *Rattus norvegicus*, for example, there is an arrangement in arches, with their summits directed medially. In at least one genus, *Lophiomys*, a suspicion of a triradius was observed. It remains to be seen what degree of individual variation, if any, occurs in the pattern. The nature of the nerve endings in this specialized apparatus will also require investigation.

Details are being published elsewhere.

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Chromosome Number of *Cardamine pratensis*

The chromosome number of *Cardamine pratensis* L. has been investigated by a number of cytologists and, as is shown in the table, several numbers have been reported.

Author	Locality of specimens	Somatic chromosome number
Manton[1]	Cambridge	*c.* 32
Manton[1]	Double varieties from botanic gardens	*c.* 64
Lawrence[2]	Merton, London	30
Flovik[3]	Spitsbergen	64
Lövkvist[4]	Southern Sweden	30, 56, 60, 64, 68, 72 and 76

The work of Lövkvist is of considerable interest in that he found a relationship between chromosome number and dampness of habitat; plants with 30 chromosomes being found in the higher parts of meadows, plants with 56–68 chromosomes being found in the lower parts and plants with 72 and 76 chromosomes near or in the water. This work also suggested that chromosome counts of wild British plants might be interesting.

Plants from three localities near Cambridge (Grantchester Meadows, Milton and Wicken Fen) and one plant from High Lane, Cheshire, have now been examined. All these have been found, from second metaphase plates of pollen mother cells (Feulgen stained squashes), to have a chromosome number of $n = 28$ (that is, a somatic chromosome number of 56). All these plants came from rather wet situations, and it also appears that Lawrence's material from the John Innes Horticultural Institution's garden came from a rather dry place. There thus seems to be some confirmation of Lövkvist's findings.

The systematic position is somewhat obscure and Lövkvist goes no further than suggesting that "*Cardamine pratensis* and *C. dentata* are probably the extremes in a series of types having more or fewer traits from the one or other of the two species". Lövkvist also states that he only found meiotic irregularities in forms having 30 chromosomes. In my material, however, two univalent chromosomes were common in the 56 chromosome plants.

My thanks are due to J. P. Cooper for the High Lane plant and to V. Chapman for making the cytological preparations.

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Chronometric Observations of the Song of *Fringilla cœlebs* Linn.

During the 1946 breeding season of the common chaffinch (*Fringilla cœlebs* L.), 5,468 observations were obtained of the song interval, that is, the time taken by the cock bird to utter his characteristic sequence of notes[1]. A split-second hand chronometer was used to record the duration of the interval to the nearest tenth of one second, and a correction was applied to eliminate the personal equation of the observer. Corrected times are considered accurate to $\pm 0{\cdot}1$ sec. No particular care was taken to ensure that successive records were obtained from the same birds, since it was desired to examine a typically representative cross-section of the local chaffinch population. Recording was made under a variety of weather conditions to assess the possible influence of certain meteorological factors on the duration and frequency distribution of the interval value defined previously.

The chief results of analysing the complete data may be briefly summarized as follows:

(i) The mean value of the song interval, based on 10-day averages of all the observations, is found to be $1{\cdot}9 \pm 0{\cdot}1$ sec. The 10-day average values exhibit a well-marked seasonal fluctuation yielding a single, flat maximum of amplitude 0·6 sec. This trend is shown by the data of Table 1.

Table 1. Seasonal march of average song interval

Days from onset of singing	5	15	35	55	75	105	125	135
Mean duration of song interval in tenth-sec.	15	16	17	20	22	22	20	18

By interpolation it is found that the maximum value of the mean song interval is attained by about the ninetieth day after the onset of singing. Both previous to, and subsequent to, this date the interval is shorter, the rate of variation being most rapid towards the end of the season (the marked rise observed between the thirty-fifth and fifty-fifth days most probably resulted from an abnormally low air temperature during the preceding twenty days).

(ii) Of the four meteorological factors studied in conjunction with the chronometric records, relative humidity affects the song interval most markedly.

Thus a change from moderately dry to damp air (60 to 90 per cent *R.H.*) shortened the average interval value from 21 to 18 tenth-seconds, a variation amounting to three times the observational error. Air temperature, degree of cloudiness and wind-strength were found to exert a significant, though less pronounced, influence on the magnitude of the song interval.

(iii) On grouping the recorded interval values in order of frequency of occurrence, a significant pattern is exhibited consisting of at least seven dominant values which range from 0·7 sec. to 3·7 sec., and are separated by an apparently constant difference of 0·5 sec. This distribution is illustrated by the data of Table 2, where the maximum frequency of occurrence has been arbitrarily chosen as 100.

TABLE 2. FREQUENCY DISTRIBUTION OF DOMINANT INTERVALS

Days from onset of singing	Dominant interval (tenth-seconds) 07	12	17	22	27	32	37
5	25	100	33	25	0	0	0
75	0	8	78	100	50	8	3
135	0	26	100	44	6	0	0

The occurrence frequency of the dominant intervals undergoes a systematic fluctuation in step with the seasonal cycle of the male bird, low values occurring around the dates of onset and cessation of singing; while higher values are restricted to the period which corresponds closely with the maximum phase of sexual activity. The causes underlying the changes just described are, in all probability, highly complex. It is hoped that other workers, more qualified to appreciate the zoological aspects of the problem, may be led to undertake further research, preferably using a microphone and electronic time-base to record the song interval objectively.

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Nov. 5.

[1] Garstang, W., "Songs of the Birds" (London: John Lane, Bodley Head, 1922).

Earliest Known Prehistoric Industry

MR. J. E. SAINTY and the late Mr. Reid Moir have reported the occasional finding, in the Sub-Crag deposits of Norfolk and Suffolk, of flint flakes which they ascribed to human manufacture. Being so sporadic, these flakes have been doubted by some (including myself) as definite indication of the presence of man or of a man-like form. My own doubts have been completely dispelled by the discovery of an excellent flake industry at this horizon occurring at five different sites near Cromer.

The industry consists mostly of side-bulb flakes produced in two fashions. They have been struck freely from undifferentiated asymmetrical and pebble cores, of the Clactonian form I have described elsewhere as the most primitive; or they have been produced by the bi-polar technique, splitting a fresh flint cobble by placing it upon another as a stock and striking with a third as a hammer. (These techniques should not be confused with the peculiarly misnamed 'block-on-block technique' said to be typical of the free-flaking Clactonian *sensu stricto*.) Most of the flakes have, necessarily, much cortex remaining on the reverse surface, but some show preparatory working associated with pebble cores.

Retouch is always from the flake surface, either free, with small 'running' flake scars, or step, closely similar to the typical Moustierian. Indeed, one specimen shows a perfect convex working edge as good as most Moustierian side scrapers. Other forms of working edge are deep and shallow single notches, points, double notches and abrupt-nosed ends. Small elongated cobbles, broken across, have been retouched on the scar edge like the so-called Darmsdenian, and large simple and asymmetrical cores have been used as hammers and choppers. One site, 13 ft. by 2 ft. 4 in. deep, has yielded an assemblage of more than three hundred flakes and tools distinctly reminiscent of the modern Tasmanian. I may add that my selection was most rigorous, involving the rejection of all pieces not certainly flakes, or showing flake scars.

The stratum, resting on Chalk, is a sub-aerial accumulation of flint cobbles weathered out over a long period and held together by sand and occasional clay, and is immediately overlain by the marine Weybourne Crag and by the Cromer Forest Bed series undisturbed with, in places, nearly 200 ft. of Pleistocene boulder clays, conglomerates, gravels, sands and loess-clays yielding palæolithic, and on top, later artefacts. Reid Moir traced the horizon beneath the Red Crag of Ipswich, making it the equivalent of the 'Stone Bed'. If this is so, the industry is pre-Pleistocene, assuming the base of the Pleistocene to be the Red Crag, the equivalent of the Rousillon, Astian and Tatrot, first glacial, and the Norwich Crag the equivalent of the Séneze, Villafranchian and late part of the Tatrot (Pinjor being first interglacial). The industry cannot be later than first glacial, but on several grounds it is most likely pre-Pleistocene.

We may confidently believe that here in East Anglia we have the most extensive sequence of prehistoric remains, and by far the earliest 'man'-made industry known to archæologists and geologists, opening up a new field of speculation on the antiquity of man.

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Nov. 20.

Combined Radar, Photographic and Visual Observations of the Perseid Meteor Shower of 1947

DURING the past two years, considerable attention has been given to the radar reflexion from the ionization produced by meteors in our upper atmosphere. Significant results using frequencies of 2·7–212 mc./s. have been published by a number of investigators in both Britain and the United States[1]. In these papers there has been a general lack of any large quantity of correlated visual data giving the accurate times and positions of the meteors in the sky.

In August 1947 the Dominion Observatory in Ottawa and the National Research Council of Canada collaborated in an effort to secure correlated radar, visual and photographic records of meteors. The radar equipment was designed and operated by the National Research Council; the visual and photographic programmes were carried out by the Dominion

Observatory. The radar operated on 32·7 mc./s., with 150 kW. peak power, 8 microsec. pulse width, and receiver sensitivity of 5×10^{-14} watt. Both transmitter and receiver employed simple horizontal dipoles oriented north–south. An *A*-scope display was used for monitoring, while a range–time display on a long-delay screen cathode ray tube was employed for recording and photographing the echoes. Visual meteors were plotted and timed to the nearest second by six experienced observers. The direct and spectrographic cameras were equipped with a synchronously driven rotating shutter covering the lens ten times per second. The radar transmitter and receiver and the main visual and photographic stations were at the radio field station of the National Research Council, four miles south of Ottawa. A secondary visual and photographic station was operated at Luskville, Quebec, twenty-two miles distant. In a total of approximately thirty hours of observation on the five nights, August 9–14, 3,700 radar echoes, 1,100 visual meteors, and 20 meteor photographs were recorded.

A total of 101 radar echoes with durations of 5 sec. or longer coincided in time (mean effective time difference 1·5 sec.) with the brighter visual Perseid meteors, mean apparent magnitude 0·5. Statistical considerations indicate that not more than three of the above number might be chance coincidences. The mean echo duration was longer for the brighter meteors, and the correlation between the radar range and the visual altitude indicated that the radar echo originated at the position of the visual meteor. If α is defined as the elongation from the radiant, meteors moving head on will have $\alpha = 0°$; those moving at right angles to the line of sight, $\alpha = 90°$. The distribution of this group of meteors with respect to α was fairly uniform, being roughly proportional to the corresponding area of visible sky (see Table 1).

TABLE 1. DISTRIBUTION OF METEORS WITH RESPECT TO α

α	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°	130°
No.	3	4	5	5	13	11	15	13	10	13	1	6	2	

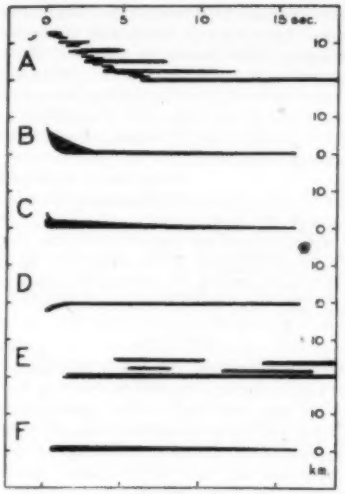
The corresponding echoes were divided into six empirical types, based on their appearance as photographed on the range–time display. The general form of each type has been sketched in the accompanying diagram. The average characteristics of the echo types have been listed in Table 2.

TABLE 2. MEAN CHARACTERISTICS OF RADAR METEOR ECHOES

Type	No. of meteors	Elongation from radiant (α in deg.)	Apparent visual magnitude	Echo duration (sec.)	Range (km.)	Total change in range
A	7	47 ± 2*	0·4	35	126	13
B	15	72 ± 2	0·9	17	140	7
C	4	74 ± 3	0·6	19	132	5
D	12	94 ± 2	1·0	23	171	3
E	19	50 ± 3	− 0·4	63	150	
F	44	5 to 125	0·7	26	160	

* Probable error of the mean.

The following additional observational facts appear evident from an examination of the echo photographs. Two basic types of echo seem to be present: (1) An echo which shows a continuous change in range, either decreasing or increasing, and which appears simultaneously with the visual meteor. Velocities deduced from this type of echo average well below the Perseid velocity of 61 km./sec., and the echo is generally restricted to meteors with α between 60° and 120°.



(2) A long-enduring echo at a discrete range (for brighter meteors several of these echoes at different ranges) which appears after the visual meteor with delays ranging from 1 to 12 sec. and which is present for all the meteors considered.

The total change in range found for the first type of echo decreases as α approaches 90°. It corresponds consistently with reflexion from a meteor path-length of about 20 km. For meteors with α near 90°, there is little or no spread in range and, though both the basic types of echo may be present, it is difficult to resolve them. The overall mean height for echoes of the second type was 99 km. and the average height difference between two echoes from the same meteor was 5 km.

Radar echoes lasting less than 5 sec. were twelve times as numerous as those of longer duration; but for these short echoes there was no significant correlation with the visual meteors in time of appearance. A total of fifty-four meteors, first magnitude and brighter, gave no echo at all on the radar.

The data presented above indicate that the strong, enduring radar reflexion from meteors is not restricted to the neighbourhood of the point where the meteor is travelling perpendicular to the line of sight. Hence, an explanation other than the geometrical one proposed by Hey, Stewart, Lovell and others must be sought to explain the discrete ranges observed. It seems logical to assume two different mechanisms for the production of the effective radar targets. The theory outlined by previous investigators would, with some modifications, account for the first basic echo type. To explain the second type a reasonably satisfactory phenomenological theory can be evolved by postulating the existence of discrete layers (fine structure) in the region in which the meteors appear. These layers are more highly susceptible to ionization from some agency (for example, ultra-violet light emitted by the meteor) than are the inter-layer spaces. Delays in the growth of the layer ionization clouds can account for the principal phenomena observed in the long-enduring echoes and might, for the short echoes, explain the lack of coincidence in time with the visual meteors. The layer theory is consistent with the sharp cut-off at minimum slant range found by Appleton and Pierce for the Giacobinid meteors.

It is not feasible to attempt to compress all the experimental data or the tentative theoretical conclusions into a short letter of this nature.

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Ottawa. MIRIAM S. BURLAND
Dec. 8. (Dominion Observatory)

[1] Bateman, R., McNish, A. J., and Pineo, V. C., *Science*, **104**, 434 (1946). Pierce, J. A., *Phys. Rev.*, **71**, 88 (1947). Appleton, Sir Edward, and Naismith, R., *Proc. Phys. Soc.*, **59**, 461 (1947). Hey, J. S., and Stewart, G. S., *Proc. Phys. Soc.*, **59**, 858 (1947). Papers by Prentice, J. P. M., Lovell, A. C. B., and Banwell, C. J., and by Lovell, A. C. B., Banwell, C. J., and Clegg, J. A., *Mon. Not. Roy. Astro. Soc.* (in the press).

THE results obtained by Dr. Millman and his colleagues represent an important contribution to the study of the complex radio echo phenomena which are observed on wave-lengths longer than 8 m. Recent unpublished British work has a significant bearing on some of the issues raised and a short summary may be appropriate.

Effect of Radio Wave-length. Simultaneous observations on two or more wave-lengths have been made of the transient echoes originating in the 100 km. region of the atmosphere, from which it appears that a striking change occurs as the wave-length is decreased from 8 m. to 6 m.[1]. Above 8 m. a very large number of radio echoes are observed independently of the presence of a major meteor shower of the 'visible' type. These echoes show a marked diurnal and seasonal variation[2,3], and are believed to be due to a uniform distribution of minute dust through which the earth is passing. As the radio wave-length is decreased, this high echo-rate disappears, and, on 6 m. and less, the transient echoes arise only from the meteors associated with the visible streams emanating from definite radiants.

Aspect Sensitivity and the Scattering Process. On wave-lengths less than 6 m. the main radio echo is obtained only when the meteor crosses the perpendicular from the station to the trail. This is immediately evident when observations are made with a highly beamed aerial system. Thus, near the peak of the great 1946 Giacobinid shower, a directional aerial system was turned into the radiant instead of at right-angles to it, and the echo-rate fell from 50 per minute to less than 0·1 per minute, although at that time the sky appeared to be full of meteors[4]. This aspect sensitivity, and the change in scattered power with wave-length from the same meteor trail, can be explained if the electrons are created by the meteor in the form of a long column of diameter small compared with the wave-length[5]. It has been realized, however, that this picture does not succeed in giving a satisfactory account of the much more complicated phenomena in the wave-length range greater than 8 m., and as Dr. Millman and his colleagues suggest, additional scattering processes must be invoked to explain the high echo-rate from invisible meteors, and the lack of aspect sensitivity.

It seems clear that in the present state of our knowledge the astronomy of the meteor streams can only be studied satisfactorily on wave-lengths less than 6 m., where the aspect sensitivity of the trails can be used to delineate radiant points by such methods as devised by Hey and Stewart[6], and Clegg[7], and where the observed echo-rates bear a very close relation to the visible meteor-rate.

The complex phenomena on longer wave-lengths are not yet understood, and further information of the Canadian experiments will be awaited with much interest.

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Physical Laboratories,
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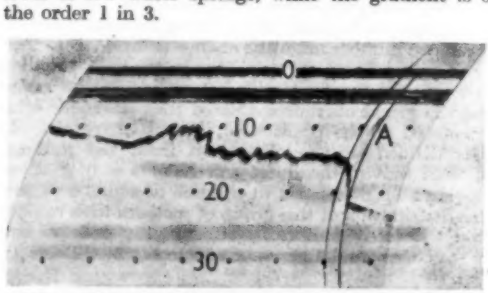
Feb. 6.

[1] Lovell, *Phys. Soc. Rep. Progr. Phys.*, **11** (1948) (in the press).
[2] Eckersley, *J. Inst. Elect. Eng.*, **86**, 548 (1940).
[3] Appleton and Naismith, *Proc. Phys. Soc.*, **59**, 461 (1947).
[4] Lovell, Banwell and Clegg, *Mon. Not. Roy. Ast. Soc.*, **107** (1947) (in the press).
[5] Lovell, *Nature*, **160**, 670 (1947).
[6] Hey and Stewart, *Proc. Phys. Soc.*, **59**, 858 (1947).
[7] Clegg (in the press).

A Submerged Ancient Cliff near Plymouth

ECHO soundings, made on the Marine Biological Association's research vessel *Sabella*, have revealed a submarine cliff, suggesting an ancient shore line, about two miles south-south-west magnetic from Plymouth Breakwater Lighthouse (see record reproduced). The height of the cliff at the section is about 33 ft., its foot rests at about 22 fathoms below the level of low water springs, while the gradient is of the order 1 in 3.



PORTION OF ECHO-SOUNDING RECORD ON COURSE S.S.W. MAGNETIC FROM PLYMOUTH BREAKWATER LIGHTHOUSE
A vertical line below the ship is represented by an arc of a circle. The distance between two dots along an arc represents ten fathoms, while the distance between two dots along a horizontal line represents the passing of 3 min. or about 650 ft. run by the ship at a quarter speed

The record of the bottom landward of the submerged cliff in 15 fathoms or less is irregular, suggesting a surface of sub-aerial denudation which has not yet been completely covered with recent deposits. Seaward of the cliff the record, with others, shows a gently sloping smooth platform suggesting a wave-cut beach possibly covered with some recent sediments. Sections across the submerged part of the Eddystone show a very rugged topography; nonetheless, there are indications at several points of the foot of a wave-cut cliff at 24 fathoms.

The formation of such a cliff would seem to need a fairly prolonged stand of the sea at a level about 22 fathoms (40 m.) lower than that of to-day, or perhaps a few fathoms lower still. If similar cliffs exist elsewhere in the English Channel, their further study may help to solve problems of sea-level during the regressions of the sea in the Pleistocene Ice Ages.

Directly above the cliff at the point marked *A* the record of a shoal of fish may be seen. The fish are reminiscent of birds soaring above a cliff in an ascending current of air. The time was within five minutes of low water at Devonport.

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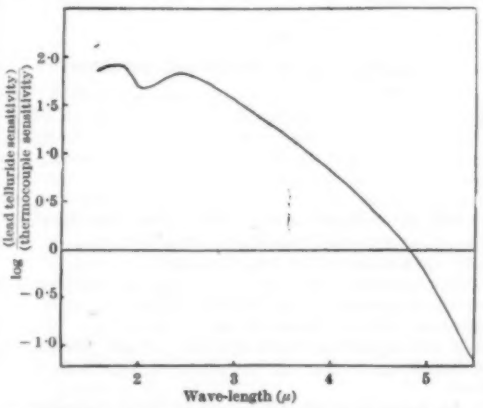
Lead Telluride Cells for Infra-Red Spectroscopy

FOLLOWING the successful development[1,2] of lead selenide photoconductive cells for the detection of infra-red radiation, we have now extended this work to lead telluride. It was known from very incomplete information that experimental cells of this material were made in Germany during the War[3] and showed some response as far as 5·8 μ, that is, considerably farther than lead selenide. However, no information was available to us on the method of preparation, nor on their performance, and it may be presumed that the absolute sensitivity was poor, in view of the widespread use in Germany of the lead sulphide cell in spite of its restriction to wave-lengths shorter than 3 μ.

As the evaporation method was used, one of the main problems was to find a window material for the base of the cell which would transmit radiation to at least 6 μ. After experimenting with various alternatives, including evaporation from small heating coils, an extremely simple solution has been found, namely, to make use of thin bubble windows similar to those used in certain ultra-violet work. It has been found that flat windows of glass approximately 20 μ thick transmit more than 90 per cent of any radiation between the visible and 8 μ, and that 'hemispherical' windows can be made which are sufficiently strong to withstand atmospheric pressure, and transmit freely to beyond 6 μ. Although some distortion of the beam occurs in passing through such a window, our results show that the effect of this on the performance of the cell is negligible.



The lead telluride cells show no photosensitivity at ordinary temperatures, and so far all the observations have been made at the temperature of liquid air. The response curve of one telluride cell to various wave-lengths is shown in the accompanying graph, in which the ordinate represents the logarithm of the ratio of the cell response to that of a Hilger–Schwarz vacuum thermocouple, the comparison being made in the same manner as for lead selenide[2]. It should be noted that at its maximum the sensitivity of the lead telluride cell is about a hundred times that of the thermocouple, that is, much the same as for the best lead sulphide cells[4]. Although the maximum of sensitivity shown by this cell lies between 2 and 3 μ, it is superior to a thermocouple up to 4·6 μ and some sensitivity is exhibited so far as 5·5 μ. As experience is gained with these cells, it may well be possible to control the position of maximum response and cause it to move to between 4 and 5 μ, as reported in the German work[3]. The time of response of these lead telluride cells is of the order of 10^{-4} sec., which is about the same as lead sulphide. It is important to note that the selenide cells which were much more rapid in response (about 10^{-5} sec.) were much less sensitive. It seems probable that there is a reciprocal relation between time of response and sensitivity for detectors of this class.

This note is primarily intended to indicate the potentialities of cells of this type for spectroscopic work, where they are clearly far superior to sulphide and selenide; full details of the method of preparation and of the properties of these cells will be published shortly.

It may be added, however, that an independent measurement of the sensitivity at 2·2 μ of a cell similar to the one used for the above tests gave a figure of 2×10^{-14} watt as the equivalent noise input (signal/R.M.S. noise) for a band width of 1 c./s. The area of the receiving surface was approximately 1 mm.[2] and the time of response $1{\cdot}5 \times 10^{-4}$ sec.

O. SIMPSON
G. B. B. M. SUTHERLAND
D. E. BLACKWELL

Cavendish and Colloid Science Laboratories,
Cambridge. Jan. 8.

[1] Simpson, O., *Nature*, **160**, 791 (1947).
[2] Blackwell, D. E., Simpson, O., and Sutherland, G. B. B. M., *Nature*, **160**, 793 (1947).
[3] Elliott, A., in "Electronics" (Edited by Lovell. Pilot Press, 1947).
[4] Sutherland, G. B. B. M., Blackwell, D. E., and Fellgett, P. B., *Nature*, **158**, 872 (1946).

High-Frequency Characteristics of Lead Sulphide and Lead Selenide Layers

RECENT work on the photoconductive effect in lead sulphide layers has suggested that the origin of both the high resistance and the photoconductive effect is in the intercrystalline barriers existing in such layers[1,5].

Impedance measurements have been made on lead sulphide and lead selenide photoconductive cells at frequencies high enough to ensure the substantial short-circuiting of these barriers. In all cases so far investigated, it has been found that as the frequency of measurement is increased the shunt resistance component of the cell impedance decreases until at about 60 Mc./s. a steady value is reached equal to a fraction of the D.C. value at room temperature. If the cell is cooled to the temperature of solid carbon dioxide (194·5° K.) or liquid oxygen (90° K.), the D.C. resistance increases exponentially in the usual manner found for semi-conductors, while the high-frequency resistance is only slightly affected. Either a small positive or a small negative temperature coefficient of high-frequency resistance is obtained, and the high-frequency behaviour is essentially semi-metallic.

For all the layers studied, the photoconductive effect decreased with increasing frequency, finally disappearing at frequencies high enough for the cell resistance to have reached a constant value.

These effects are illustrated in Figs. 1 and 2 for a lead sulphide cell which had been manufactured by a vacuum evaporation process.

Fig. 1 illustrates the variation of cell resistance with frequency at two temperatures, measurements being made with the cell illuminated and unilluminated.

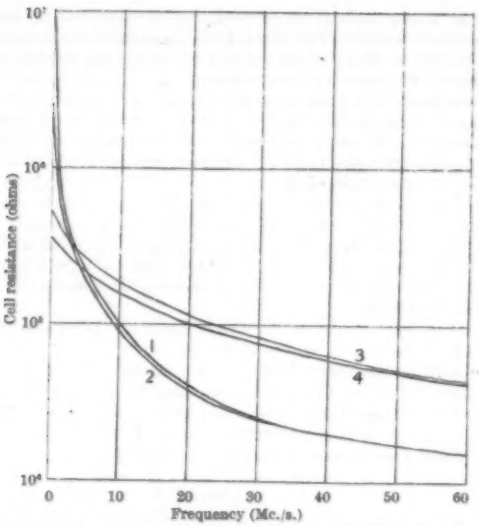


Fig. 1. Curves 1 and 2 ; 194·5° K., cell in darkness (1), illuminated (2).
,, 3 ,, 4 ; 297° K., ,, ,, ,, (3), ,, (4).

Fig. 2 gives an indication of the variation of cell resistance with temperature at low- and high-frequencies. The direct variation of cell resistance with temperature has not yet been determined at the high frequency, so it is hoped to make this the subject of a future experiment.

On the basis of the above results it would seem reasonable to draw the following conclusions :

(*a*) The presence of the photoconductive effect is associated with the intercrystalline barriers, as it disappears when these are short-circuited.

(*b*) The microcrystals constituting the photoconductive surface the impedance characteristics of which are measured at high frequencies are themselves semi-metallic in nature, thus indicating a high impurity content, resulting in energy-levels near the conduction band ; this fits in well with the measurements made by Dunaer[2] and Bauer[3] on single crystals.

One apparent anomaly should be mentioned. Approximate values for the layer dimensions are length = 1 cm. ; width = 1 mm. ; thickness = 3×10^{-4} cm. Taking a high-frequency value for the resistance of 5×10^4 ohms, we find for the conductivity of the microcrystals a value of 0·01 ohm^{-1} cm.$^{-1}$ approximately.

This is of the order of a thousand times less than the usual values for impure semi-metallic single crystals[4]. Some explanation for this may perhaps lie in the fact that owing to the random size and shape of the microcrystals, the effective contact area of the crystals is considerably smaller than the size of the crystals themselves.

The above work was carried out in the laboratories of the Telecommunications Research Establishment (Ministry of Supply), and thanks are due to Mr. P. Handley (University of Oxford) and Mr. J. Newton (University of Cambridge), who assisted with the measurements described during their summer vacation.

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Telecommunications Research Establishment,
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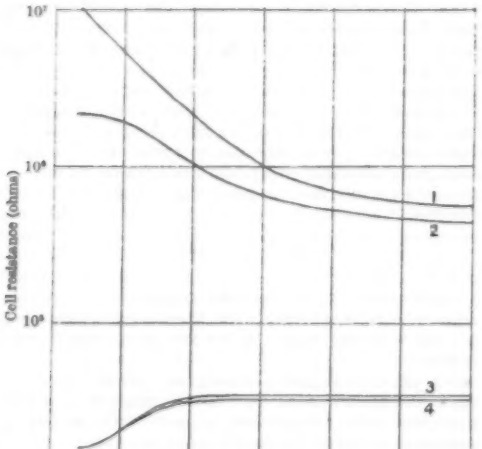
Nov. 20.

[1] Sosnowsky, Starkiewitz and Simpson, *Nature*, **159**, 818 (1947).
[2] Dunaer, *C.R. Acad. Sci. U.S.S.R.*, **55**, No. 1 (1947).
[3] Bauer, *Ann. der Phys.*, **38**, 84 (1940).
[4] Eisenmann, *Ann. der Phys.*, **38**, 121 (1940).
[5] Simpson, [*Nature*, **160**, 791 (1947).]



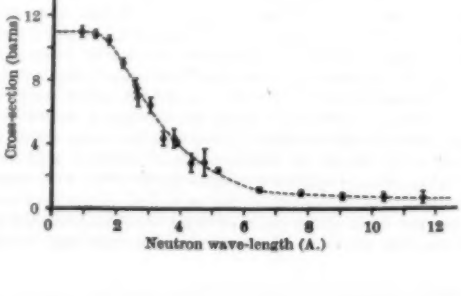
Cell warming from 194·5° K. to room temperature (297° K.)
Fig. 2. Curves 1 and 2 ; 1590 cycles, cell in darkness (1), illuminated (2).
,, 3 ,, 4 ; 50 megacycles, ,, ,, (3), ,, (4).

Scattering of Neutrons by Lead

The University of Cambridge cyclotron and neutron velocity selector have been used for studying the scattering of neutrons by lead. The scattering cross-section as a function of the neutron energy was determined by measuring the number of neutrons scattered out of a collimated beam into a boron trifluoride counter placed near a cast lead scatterer. Neutrons scattered through angles between 30° and 150° (approximately) were counted.

The results show that the scattering cross-section, which is assumed to be 11 barns (1 barn = 10^{-24} cm.^{2}) at short neutron wave-lengths, drops to a value of $0{\cdot}6 \pm 0{\cdot}3$ barn at wave-lengths greater than about 6 A., owing to the microcrystalline structure of the lead.

No scattering should occur at long wave-lengths from an ideal lattice composed of identical coherent scattering centres. The observed residual scattering is the sum of contributions arising from thermal



vibrations, crystal defects, the presence of isotopes, and the different orientations of the nuclear spin. The experiment, therefore, fixes an upper limit to the residual scattering caused by the presence of several isotopes in lead:

$$s_{is} \leqslant 0{\cdot}6 \pm 0{\cdot}3 \text{ barn},$$

which does not disagree with the upper limits of 1·6 and 2·5 barns set by transmission measurements[1,2].

If we use the scattering length a as defined by Fermi[3], the normal random scattering cross-section is given by

$$\sigma = 4\pi \Sigma_r p_r a_r^2,$$

and the coherent scattering cross-section relevant in single crystal diffraction is

$$s = 4\pi \left(\Sigma_r p_r a_r \right)^2.$$

The three cross-sections are related by the simple equation:

$$s_{is} = \sigma - s = 4\pi(\overline{a^2} - \bar{a}^2).$$

Since s_{is} is so small, it is evident that the minimum value of s is about 10 barns, and so the scattering lengths of all the major lead isotopes must be nearly equal. This is reasonable, since the small capture cross-section shows the absence of nearby resonances.

This result is in disagreement with the tentative value for s of 2·9 barns deduced by Fermi and Marshall[3] from measurements on a lead sulphide crystal. Substitution in their results of form factors modified in accordance with $s = 10$ barns certainly gives an uneven decrease of intensity with order of reflexion, and it is not clear at present how this arises.

R. Latham
J. M. Cassels

Cavendish Laboratory,
Cambridge. Nov. 14.

[1] Fermi, E., and Marshall, L., *Phys. Rev.*, 72, 408 (1947).
[2] Havens, W. W., Rabi, I. I., and Rainwater, L. J., *Phys. Rev.*, 72, 634 (1947).
[3] Fermi, E., and Marshall, L., *Phys. Rev.*, 71, 666 (1947).

Production of Nitrogen Atoms in the Upper Atmosphere

Evidence has accumulated in recent years that nitrogen is at least partially dissociated in the upper atmosphere. However, thus far the precise process causing the dissociation of nitrogen has not been established, except that it has been suggested that only the extremely short ultra-violet beyond 500 A. could produce it[1].

Recently, R. Herman[2], under certain conditions of discharge, found a breaking off above the level $v' = 6$ in the Lyman–Birge–Hopfield ($a-X$) bands of nitrogen. We have confirmed this breaking off in nitrogen excited at low pressure in a high-frequency electrodeless discharge. The appearance of our spectra leaves no doubt that we have here a predissociation of the N_2 molecule. The predissociation limit is between the levels $v' = 6$ and 7 of the $a\ ^1\Pi_g$ state at an energy of approximately 9·8 eV., which agrees closely with the energy necessary to dissociate N_2 into $N(^4S)$ and $N(^2D)$, assuming $D(N_2) = 7{\cdot}38$ eV. The $a-X$ bands are the only absorption bands of N_2 above 1150 A. (see Birge and Hopfield[3]). The absorption is comparatively weak, since the bands represent a forbidden transition (see G. Herzberg[4]).

The $v' = 0$ progression has been observed in absorption from the 0—0 to the 9—0 band. The 7—0, 8—0 and 9—0 bands have the wave-lengths 1249·3, 1226·6 and 1205·3 A. respectively. Absorption of solar radiation of these wave-lengths will lead to the production of nitrogen atoms in the upper atmosphere, since the molecules in the upper levels will undergo predissociation. The observation that in the laboratory the predissociation becomes noticeable only at low pressures indicates that the predissociation is a forbidden one. Nevertheless, in the upper atmosphere, a considerable fraction of the excited molecules will predissociate rather than return to the ground-state with emission of fluorescence.

On account of the comparatively low transition probability of the $a-X$ bands, the formation of nitrogen atoms according to the above mechanism will go on over a very considerable range of heights, particularly since in the region 1150–1250 A. absorption by oxygen molecules is comparatively weak. It is thus possible to account both for the presence of nitrogen atoms at comparatively low heights and for the presence of nitrogen molecules at much greater heights (as observed in auroras).

While it is conceivable that nitrogen atoms may also be produced at much shorter wave-lengths through different mechanisms, we feel, in view of the much greater intensity of solar radiation at 1200 A. than at the shorter wave-lengths, that the mechanism here established is by far the predominant one.

The production of nitrogen atoms by predissociation in the $a-X$ bands is independent of the correctness of the value of $D(N_2)$ assumed above. If one assumes Gaydon's value[5], the predissociation would lead to two normal atoms rather than one normal and one excited atom. However, it may be mentioned that the type of predissociation observed points strongly to the lower dissociation energy. Experiments are in preparation to settle this question definitely.

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Oct. 29.

[1] See Wu, T. Y., *Phys. Rev.*, 66, 65 (1944).
[2] Herman, R., *C.R. Acad. Sci. Paris*, 217, 141 (1943); *Ann. de Phys.*, (11), 20, 241 (1945).
[3] Birge, R. T., and Hopfield, J. J., *Astrophys. J.*, 68, 257 (1928).
[4] Herzberg, G., *Phys. Rev.*, 69, 362 (1946).
[5] Gaydon, A. G., "Dissociation Energies and Spectra of Diatomic Molecules" (London, 1947).

Calculation of the Piezo-electric Constants of α- and β-Quartz

α-Quartz possesses only two piezo-electric constants, ε_{11} and ε_{14}, given by the equations

$$\left.\begin{aligned} p_x &= \varepsilon_{11}(u_{xx} - u_{yy}) + \varepsilon_{14} u_{yz} \\ p_y &= -\varepsilon_{11} u_{xy} - \varepsilon_{14} u_{zx} \\ p_z &= 0 \end{aligned}\right\}, \qquad (1)$$

where p_x, p_y, p_z are the electric moments per unit volume developed on strain along the axes of the crystal, and u_{xx}, u_{xy}, etc., the components of strain. β-Quartz, which possesses a higher symmetry, has only one constant, ε_{14}, the other, ε_{11}, being zero. A method of deriving the above equations from the structure of the crystal, that is, the co-ordinates of the atoms in the unit cell, is not known. While the earlier work of Curie[1] (1882), Riecke[2] (1892) and Kelvin[3] (1893) is purely speculative, Gibbs[4] (1926) calculated the piezo-electric modulus δ_{11} on the basis of his structure and obtained a value which is nearly five times too high. Moreover, he did not calculate the other constant, δ_{14}, and did not show how the

above equations can be obtained from his co-ordinates. We have been able to derive the above equations from the structure of Gibbs and have in this way obtained values of ε_{11} and ε_{14} which agree completely with the observed values. The piezo-electric constant ε_{14} of β-quartz and the variation of ε_{11} and ε_{14} with temperature in the case of α-quartz has also been calculated.

α-Quartz is a crystal with covalent bindings. The electric moment may therefore be supposed to arise from the displacements of the silicon and oxygen atoms in close neighbourhood. As each silicon is linked to four oxygens and each oxygen to two silicons, six Si—O bonds—there are twelve Si—O bonds in the unit cell—will correspond to a charge $k_1 e$ on each atom and the remaining six to a charge $k_2 e$. In β-quartz, k_1 is equal to k_2, since all the bonds are equivalent.

It can be shown that in a general elastic deformation, the changes in the length of a line after strain, and the changes in the angles between two lines after strain, are completely given in terms of the strain components u_{xx}, u_{xy}, etc., and are independent of the rotation components ω_x, ω_y, ω_z (*vide* Love[5]). Any change Δr in the length of an Si—O bond would produce a moment $ke\Delta r$ in that direction, but the direction cosines of the line after strain are not known, since they involve the rotation components ω_x, ω_y, ω_z. We therefore take three points P, Q, R, such that P and R are silicon atoms and Q an oxygen atom, or *vice versa*, and resolve the electric moments due to the displacement of atoms in the plane of the Si—O bonds, PQR and perpendicular to this plane.

Since the components of strain u_{xx}, etc., are very small quantities, it is easy to show that the moments in the plane PQR may be regarded as produced by a change in the bond directions before strain, and the moment normal to the plane may be taken as half the value of the moment normal to the plane when the displacements of the atoms P, Q, R are entirely normal to the plane. This would be justifiable, since in an elastic deformation of the unit cell, the moments due to 36 O—Si—O planes and 6 Si—O—Si planes have to be considered.

If l, m, n are the direction cosines of Si—O bonds, and p, q, r of the normals to the various planes, we get in summing over all these planes:

$$p_x = \frac{e}{v}\left[\Sigma^{\text{12 Si—O bonds}} k \,.\, \Delta r \,.\, l\right] +$$

$$\frac{e}{8v}\left[\Sigma^{\text{18 O—Si—O planes and 6 Si—O—Si planes}}\left\{\frac{k_1+k_2}{2}(\Delta r_1 - \Delta r_2)\cot\alpha + \frac{k_1-k_2}{2}\,\frac{r_3\,\Delta r_3 - r(\Delta r_1+\Delta r_2)(1-\cos 2\alpha)}{r\sin 2\alpha}\right\} p\right];$$

with similar expressions for p_y and p_z; here $PR = r_3$; Δr_1, Δr_2, Δr_3 are the variations of PQ, QR and PR; $r = PQ = QR$; $\angle PQR = 2\alpha$; v = the volume of the unit cell.

These expressions resolve into equations (1) by giving p, q, r suitable signs. The calculation shows that the moments in the plane of the Si—O bonds (the first part of the above expression) make no contribution to the transverse coefficient ε_{14}. Assuming that the moments normal to the plane of the bonds give no contribution to the longitudinal coefficient ε_{11}, we find that if $\varepsilon_{11} = 5{\cdot}1 \times 10^4$ we get $k_1 = 0{\cdot}752$, $k_2 = 0{\cdot}695$, and $\varepsilon_{14} = 1{\cdot}23 \times 10^4$, in complete agreement of the observed values.

A similar calculation when applied to β-quartz gives $\varepsilon_{11} = 0$, and $\varepsilon_{14} = 1{\cdot}07 \times 10^4$ for a non-ionic crystal ($k = 0{\cdot}724$) and $1{\cdot}47 \times 10^4$ for an ionic crystal ($k = 1$). If the moments perpendicular to the plane of the bonds are supposed to give no contribution to the longitudinal coefficient, we find $k_1 = k_2$, which is the case in β-quartz. The assumption is therefore justified.

The variation of ε_{11} with temperature in α-quartz can be completely explained on the basis of change of co-ordinates with temperature. It is found that at 558° C. the silicon atoms in α-quartz occupy the same positions as they do in β-quartz. As the transition temperature is reached, the longitudinal coefficient in α-quartz drops to zero, but the transverse coefficient changes only by 12 per cent.

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Sept. 3.

[1] Curie, *C.R. Acad. Sci., Paris*, **95**, 914 (1882).
[2] Riecke, *Abh. Ges. Wis. Gött.*, **38**, 530 (1892).
[3] Kelvin, *Phil. Mag.*, **36**, 331 (1893).
[4] Gibbs, *Proc. Roy. Soc.*, **110**, 443 (1926).
[5] Love, "Math. Theory of Elasticity", 38 and 39.

Max Planck

In a broadcast talk on Max Planck, in which whole-hearted tribute was paid to his great work, I used the words, "If I hesitate to put Planck on a level with Newton and Einstein it must be partly on the ground that he did not seem to know quite what he had done when he did it . . . Planck seems to have been reluctant to realize the range of his innovation." I was, of course, basing my opinion upon his published work. I have just received a letter from Frau Planck, his widow, who has read the talk as printed in the *Listener* of November 6, 1947, p. 811, in which she says, "You have done justice to the scientist and to the man in every respect. I should only like to make one small exception. You think that he did not realize the scope of his discovery. Yet he did do so—though of course not in all its consequences. He said to our son with whom he had gone through a book on Galileo, Newton and Kepler, 'Look, my boy, I shall one day be in a book like this'. And to our other son he spoke as Sommerfeld has set it down." The reference is to an article of Prof. Sommerfeld's (*Die Neue Zeitung*, November 6, 1947), which I have received both from her and from Sommerfeld, where the following passage occurs: "Planck realized the scope of his discovery from the beginning. This is clear from an anecdote which Professor Bavinck, who died recently, repeated to me on the occasion of his lecture at Munich this year: he had it from his friend Erwin Planck, the son of the great man. The father said to the son in 1900, on the occasion of a walk in the Grünewald, 'Today I have made a discovery which is as important as Newton's discovery'."

Naturally both these conversations were unknown to me and do not affect the point that there is nothing in his writings to indicate this early realization of the importance of his discovery. They seem to be of sufficient general interest for the historian of science to warrant me laying them before the readers of *Nature*.

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STONYHURST COLLEGE OBSERVATORY

THE closing of Stonyhurst Observatory on December 31, 1947, brings to an end more than a century of scientific work. Founded in 1838, the Observatory has been staffed and maintained by the Society of Jesus. Its first work was purely meteorological, and this has been continued throughout its existence. The Royal Society Commission, which in 1867 replaced the Board of Trade in the organisation of meteorological observations in Britain, selected Stonyhurst as one of the seven principal stations, each of which it supplied with standardized equipment and continuously recording instruments. For many years these stations formed the mainstay of British meteorology.

Stonyhurst Observatory was, however, early in its existence, to extend its activities to geophysics and astronomy. At the instance of Sir Edward Sabine, regular magnetic measurements were started by Perry in 1861, and continuous magnetic recordings a few years later. During the years 1868–70, Perry and Sidgreaves carried out an extensive magnetic survey of France and Belgium. In more recent years, seismology has also been included in the regular programme.

Astronomical work had already engaged the attention of Stonyhurst when the Observatory gave refuge to Secchi during the Italian troubles of 1848. Perry's interest in solar physics defined the direction which this work was to take. In 1881 he commenced the series of daily solar drawings, which were included in the routine of the Observatory for sixty years. To these drawings Sidgreaves and Cortie added the spectroscopic study of sunspots. In their pioneer research on the *B*—*D* region, which supplemented the work of Lockyer and Smart, they were among the first to detect molecular bands, and to identify the numerous vanadium and titanium lines. In addition, Cortie found time to use the material provided by the simultaneous solar and magnetic observations for an independent analysis of the interrelation of solar and geophysical phenomena.

During the years 1870–1914, the Stonyhurst astronomers played leading parts in a number of scientific expeditions, including both the transits of Venus (1874 and 1882), and seven solar eclipses. Astronomers will remember in particular the Royal Astronomical Society's eclipse expedition to French Guiana in 1889, which Father Perry led to a successful conclusion only at the cost of his life.

The considerable programme of solar and geophysical work and the relatively modest equipment of the Observatory made a continuous programme of stellar work impracticable. The occasional researches, mainly on the spectra of novæ, carried on within these limitations, were not for that reason desultory or ephemeral, but showed at times an eye for experimental technique of which a larger institution would not have felt ashamed. Stonyhurst was one of the few observatories to secure photographic spectra of Nova Aurigæ in 1892, the first nova to be so photographed. For this purpose Sidgreaves and Cortie used a slitless spectrograph with a collimated beam, instead of the objective prisms used at Harvard and at South Kensington. In this they anticipated Wadsworth's suggestion by a decade, and its common adoption by a still longer time. A similar ingenuity stamped the attempt to apply Orbinsky's length-of-spectrum method to the measurement, from objective-prism spectra, of the radial velocity of the expanding shell of Nova Aquilæ (1918). The astronomical work of Stonyhurst will always be associated with the name of Perry, but scarcely less credit is due to the originality of Sidgreaves, and the effective collaboration of O'Connor. While not so great an astronomer, Cortie contributed much to the spread of astronomical knowledge among a wider public.

The growing disparity between modern observational needs and the limited equipment of a private observatory has caused Stonyhurst in more recent times to return to the geophysical and meteorological work for which it was originally founded. This selfless task has been performed for many years by Father J. P. Rowland, the retiring director, whose advancing years and failing health have precipitated an inevitable though regretful decision. He will have the satisfaction of having completed a century of recording, and will terminate, temporarily at least, a line of priest-scientists whose solid achievement in their self-imposed task will be most readily admitted by their fellow physicists and astronomers.

P. J. TREANOR

THE ASSAYING OF PENICILLIN

THE first joint meeting of the Biological Methods and the Physical Methods Groups of the Society of Public Analysts and other Analytical Chemists, held on January 29 in the Barnes Hall of the Royal Society of Medicine, was devoted to methods of penicillin assay—their purpose, scope and validity. The plenitude of highly ingenious assay techniques in the chemical and physical and in the biological fields respectively were briefly surveyed by the opening speakers of the two sessions, Dr. E. Lester Smith and Dr. N. G. Heatley. A dozen or so specialized physical instruments have been pressed into service, several for more than one method, as have many more distinct chemical reactions and physical and microbiological techniques not involving instruments.

There were really two distinct problems under discussion, namely, the assay of *total* penicillin, and the assay of *individual* penicillins, at least five of which are now recognized as liable to be present in appreciable proportions in commercial penicillin supplies. It is perhaps clearer to adopt this division of the papers and discussions, rather than into non-biological and biological methods, as was done at the meeting.

Total penicillin may be assayed non-biologically with the aid of the polarograph, polarimeter, colorimeter (three methods), fluorimeter, ultra-violet spectrophotometer or Warburg manometer. Nevertheless, most of the people who do daily routine assays have simpler tastes and appear to favour the burette. Many of the other methods are now only of historical interest; the trouble with some of them is that they require more labour to carry them out than the biological methods they seek to replace, without offering adequate advantages by way of compensation. It is only fair to add that the biological methods have themselves been streamlined to cut down manipulation and improve accuracy, since some of these tests were invented in the early days of penicillin manufacture.

Two titration methods are available, each with minor variants. The first, the subject of a paper read by Miss S. J. Patterson, commends itself by extreme simplicity, being virtually a determination of saponification value. Dilute alkali quantitatively opens the

β-lactam ring of penicillin in an hour or so at room temperature, whereupon the unused excess alkali is back-titrated to the cresol red end-point. The other, the iodometric method, involves somewhat more manipulation but is perhaps rather more specific; also, being much more sensitive, it is applicable, for example, to the assay of lozenges and other pharmaceutical products. It depends on the fact that the product of alkaline hydrolysis, penicilloic acid, is vigorously oxidized by iodine, consuming about eight atoms per molecule, whereas penicillin itself is not attacked: thus a blank determination, omitting only the hydrolysis step, corrects for oxidizable impurities.

The avowed object of the meeting was to discuss the "purpose, scope and validity" of the methods, and the speakers at the earlier session took this very seriously. Indeed, so frankly did they point out the limitations of their methods, that during the tea interval biologists could be heard proclaiming that their own methods remained virtually unchallenged. This, however, would be an unfair conclusion; despite the unavoidable uncertainty as to the proper factor for conversion to biological units, when assaying mixtures of penicillins, these non-biological methods have their place in routine control. They offer the advantages of speed and moderately high accuracy with a minimum of labour.

The biological methods have their shortcomings too, as we learned later; for example, when one speaker gave as an advantage of the turbidimetric over the plate diffusion methods, that it was less liable to break down completely and invalidate a whole day's assays. There are fundamentally three methods with innumerable variants. The earliest, the serial dilution method, appeared to engender depression among its devotees from the fact that the result is given by only one tube out of the six or more that must be set up for each test. Accordingly two speakers, Dr. C. G. Pope and Mr. C. R. Bond, described turbidimetric methods that appear to give greater æsthetic satisfaction as well as greater accuracy, from the fact that several tubes of the series are measured. The third group of methods, most widely used for routine control, are those depending on diffusion of penicillin from a hole in, or a cup, spot or disk of blotter upon, a sheet of agar seeded with a suitable organism, usually *B. subtilis* or *S. aureus*. A curious point was made by Dr. N. G. Heatley that merits some explanation: in the hole or cup techniques, the diameter of the ring of inhibition is controlled by the *concentration* of penicillin and not the total amount used, whereas in the spot or blotter-spot techniques, it is the *total amount* that matters irrespective of concentration. The Japanese, perhaps from a shortage of Petri dishes, apparently prefer vertical diffusion techniques, using test-tubes of seeded agar overlaid with the penicillin solution.

The biologists have the field almost entirely to themselves when it comes to assaying penicillin in body fluids. Some other methods will deal with penicillin solutions as dilute as these, but scarcely in the presence of so much interfering material, which indeed can cause errors in the biological methods too. The diffusion methods are not usually sensitive enough, unless an organism hypersensitive to penicillin is employed. Serial dilution methods are generally used, with micro tubes, capillaries or even single drops on microscopic slides.

Turning now to the determination of individual penicillins, this may be tackled by X-ray crystallography, or better by infra-red or ultra-violet spectrophotometry, as described by Dr. G. H. Twigg. The infra-red method, employing alanine or cystine as internal standard, exploits characteristic absorption bands for each penicillin species. At present it is limited to the examination of sodium salts in crystalline form, and accuracy is conditioned by the difficulty of preparing a uniform suspension of sample and standard in liquid paraffin. The other methods also have their snags and are mostly adapted to determine only one of the penicillins, usually benzylpenicillin (penicillin G or II). The few purely chemical methods have the same defect and were dismissed as of low accuracy. Much more satisfactory are the physical methods described by Dr. W. R. Boon, involving partition between buffer solutions and organic solvents, preferably ether. The very limited value of separating funnels may be enhanced by the counter-current apparatus of Craig. Complete separation of all the penicillins, however, demands chromatography on buffered silica columns or strips of filter paper, techniques developed by Dr. Boon's colleagues. He spoke of the difficulty of securing completely satisfactory separations on the silica columns (except of penicillin K), criticizing some American publications on the subject: another disadvantage is the destruction of 25 per cent or so of the input penicillin. The paper-strip method, on the other hand, can effect even the most difficult separations quantitatively under suitable conditions.

An interesting application of this technique is in checking the purity of penicillin standards. The International Standard, for example, was found to contain a few per cent of penicillins other than benzylpenicillin (G). Another application is in checking the specificity of a chemical method that has been adopted officially in the United States. It depends upon the precipitation of the crystalline salt of penicillin G with N-ethyl piperidine on adding this base to an amyl acetate extract of the penicillin, in presence of acetone. Dr. Boon stated that other penicillins are also precipitated from mixtures and that penicillin G is not obtained pure even on putting the precipitate through the process a second time. This lack of specificity was confirmed by Dr. Smith during the discussion: he had also found, using the same technique, that part of the penicillin G appears in the filtrate.

It was now the turn of the biologists to be discomfited, for their differential assay methods (using two organisms) came in for some pointed comments on account of their continued application to complex mixtures of penicillins, as well as to the binary mixtures for which they were designed. They retaliated by attempting to claim from the physicists the paper-strip microchromatographic method, on the ground that the penicillin zones are rendered visible by biological means (as zones of inhibition on seeded agar). It was, indeed, remarkable how unanimous the speakers were in praise of this method, although one wondered if this was not due more to despair of the other methods, and admiration for its originality and extreme elegance, than to any proof presented as to its accuracy. Its originators themselves admit that it is still in need of refinements and of a more precise check on its accuracy, using known mixtures of pure penicillins. Nevertheless it remains the only method capable of measuring all the penicillins simultaneously, yet simple enough for routine use.

Dr. Pope recorded the observation that nearly equal *weights* of penicillins G and K are adsorbed by

suitable amounts of a washed charcoal; since the biological activities of these penicillins against *S. aureus* differ considerably, the amounts adsorbed *in units* also differ sufficiently to form the basis of an assay method. Like the differential assay methods, it is not applicable to more complex mixtures.

In vivo tests have been suggested for the determination of heptylpenicillin (K) in mixtures based on the observation that the protective value of this penicillin against experimental infections is much smaller than that of all the other common ones, namely, Δ^2 pentenylpenicillin (F or I), amylpenicillin (dihydro F), benzylpenicillin (G or II), and *p*-hydroxybenzylpenicillin (X or III). Such a test is naturally slow and expensive and of low accuracy. Its main value lies clearly in establishing the relative therapeutic efficacy of the penicillins rather than for assay of mixtures. Such work has recently produced some evidence for enhancing effects of one penicillin upon another, and also of two or three substances present in some crude penicillin supplies upon pure penicillins of all types.

Sir Alexander Fleming, opening the discussion after the second session, expressed his admiration for, and astonishment at, the galaxy of physical and chemical methods; but pointed out that the biological methods, though now more refined, were fundamentally those originally used in the discovery of the antibacterial activity of penicillin. Finally, Dr. A. A. Miles, director of biological standards at the National Institute for Medical Research, drew together and sorted the tangled threads of the discussion in a speech as witty as it was concise.

The full papers and discussion will be published in due course in the *Analyst* and also in booklet form.

LONG-DISTANCE CORRELATION OF BOULDER CLAYS

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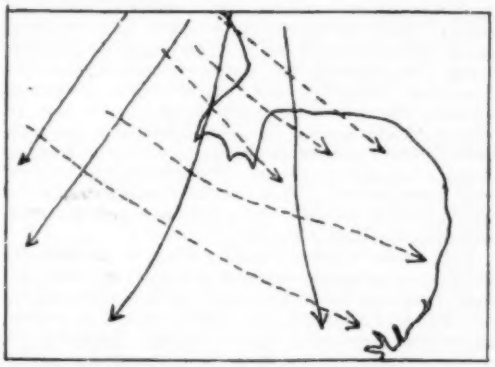
RESEARCH work on the glacial deposits of East Anglia during the last few decades has been directed mainly towards: (1) the establishment of a sequence of deposits; and (2) the discovery of the direction or directions in which the ice has travelled, as shown by the contents of the various beds. In order to combine these two lines of approach, I have recently undertaken a fresh examination of the glacial deposits, especially the boulder clays, and having determined some of the changes in ice-direction, have found that certain long-distance correlations which have been made, especially by Prof. P. G. H. Boswell, are strongly confirmed.

Knowledge of the glacial succession in East Anglia has accumulated very gradually, and the contributions of a number of geologists culminated in the sequence published in 1931 by Boswell[1]. Few alterations or additions have been made since that date, except in nomenclature, and the present state of our knowledge on the subject seems to be:

Youngest
Hessle Boulder Clay (Brown Boulder Clay at Hunstanton).
March Gravels (and probably the Brundon Gravels).
Upper Chalky Boulder Clay (Solomon's 'Little Eastern')[2].
Hoxne Interglacial.
Lower Chalky Boulder Clay (Solomon's 'Great Eastern').
Corton Beds (Wood's 'Middle Glacial')[3].
Cromer Tills (included in 'North Sea Drift').
Oldest

Of the three boulder clays observed by Paterson[4] in the Breckland, the Upper Boulder Clay of that area is Boswell's Upper Chalky Boulder Clay, and the Middle and Lower Boulder Clays described by Paterson may be the equivalents of the Lower Chalky Boulder Clay and one of the Cromer Tills respectively, but further evidence is needed on this point.

Comparatively little work has been done on the direction of ice-movement as shown by the contents of the various boulder clays, although Harmer[5] showed that some of the material in the 'North Sea Drift' had come from a general northerly direction, whereas much of the content of the 'Great Chalky Boulder Clay' was obviously derived from the north-west, including Jurassic rocks from the Fenland. Harmer suggested that the ice-sheet responsible for that boulder clay fanned out from Fenland in several directions, eastward across Norfolk and Suffolk, southward towards London and westward up the valleys of the Great Ouse, Nene and Trent. The drifts carried during this fanning-out process are shown by symbols on the well-known map which accompanied his paper; but a detailed examination of this map shows that there are many contradictions to the 'fanning-out' theory, and in any case the exact date in Boswell's sequence at which this process took place is unknown.



DIRECTIONS OF ICE-MOVEMENT IN EASTERN ENGLAND. UPPER CHALKY BOULDER CLAY, →; LOWER CHALKY BOULDER CLAY, - - →

A fresh examination has therefore been made, especially of the chalky boulder clays of Suffolk, the results of which are now sufficiently advanced to prove that the Lower Chalky Boulder Clay of that area is the darker-coloured clay containing much Jurassic material, whereas the Upper Chalky Boulder Clay is paler, and contains more chalk and igneous rocks, and has come from a more northerly direction, and to the eastward of the Lincolnshire Wolds. It is therefore the Lower Chalky Boulder Clay which Harmer described as bringing Jurassic material across the Fenland from west of the Lincolnshire Wolds. The directions of these two independent ice-sheets are indicated on the accompanying sketch. These conclusions are based on the assumption that the Upper Chalky has picked up more chalk than the Lower Chalky, because its direction of movement nearly coincided with the strike of the chalk, whereas that of the Lower Chalky corresponded more nearly with the dip of that formation, and therefore crossed a smaller area of its outcrop. The foregoing observation refers to the strike of the chalk in Norfolk and Suffolk, with a direction approximately from north

to south between Hunstanton and Mildenhall, and continuing south-west by Newmarket towards Royston.

The intensely chalky boulder clay of the Cromer district[2], on the other hand, can belong to the Lower Chalky glaciation, because ice from the north-west in northern Norfolk would have passed along the strike of the Lincolnshire chalk.

Apart from the matrix of the boulder clays, these ice-directions are confirmed by such erratics as have been collected *in situ* in the boulder clays. The Lower Chalky at Claydon, near Ipswich, contained flint, hard chalk, Neocomian sandstone, Red 'Chalk' (very rare, and doubtfully *in situ*), Septaria, Kimmeridge Shale, Oolite (probably from Lincolnshire), *Gryphæa* cf. *incurva*, Bunter quartzites, blue limestones (? Carboniferous or Jurassic), ? Millstone Grit and non-porphyritic basalts (which may be from Derbyshire). At Bawsey, east of King's Lynn, collection included flint, hard chalk, Neocomian Sandstone, *Terebratula* cf. *rosenkranzi* and *Pavlovia* cf. *worthensis* (Portlandian), and possibly Bunter pebbles. The same boulder clay at Pakefield, near Lowestoft, yielded similar Cretaceous and Jurassic rocks, including *Ostrea dilatata*, *Ostrea delta* and *Pachyteuthis abbreviata*. The Lower Lias is probably represented by *Lima hermanni*. The Lowestoft boulder clay also contains Bunter quartzites, blue limestone (? Carboniferous), basalt and a small rounded pebble of schist. This last erratic is probably derived from the underlying Corton Beds. If the long list of Jurassic fossils from Ormsby St. Margaret, published in the Geological Survey Memoir (Yarmouth), is taken into account, the Lower Chalky Boulder Clay is seen to consist of Cretaceous, Jurassic, Trias and probably Carboniferous pebbles in a matrix of various Jurassic clays. No other igneous or metamorphic erratics were found *in situ*. This boulder clay appears to be the product of Pennine Ice, which has travelled south-east across mainly Jurassic outcrops.

The Upper Chalky Boulder Clay is consistently different. Cretaceous material is much more common than Jurassic. Red 'Chalk' is abundant, especially at Claydon and Bolton's pits near Ipswich, also blue-and-white flint with the so-called 'basket-work' patina, which is not known to occur in the Lower Chalky. The Upper Chalky also contains Bunter pebbles, porphyrites of supposed Old Red Sandstone type, ? volcanic tuff, various felspathic grits and a sandstone with abundant tourmaline (at Hoxne). An erratic of rhomb-porphyry was found some years ago by Miss Tomlinson close to Upper Chalky Boulder Clay in Bolton's pit, Ipswich. Such Jurassic fossils as occur rarely could be derived from the Lower Chalky Boulder Clay. The Upper Chalky is therefore a deposit containing much flint, and erratics from apparent Scottish Old Red Sandstone, with others which could be derived from one of the Cromer Tills, in a matrix of sand and soft chalk. It appears to represent Scottish Ice, which has entered west Norfolk and Suffolk from a northerly direction off the existing Lincolnshire coast.

These two boulder clays are not often seen in direct superposition, but they are exposed together in the pit at Claydon, and have been seen in former sections at Hoxne and Derby Road brickworks at Ipswich (where the Upper Chalky is decalcified), at Bolton's pit, and probably elsewhere. Most of the Acheulean and associated implements of the Ipswich district come from interglacial deposits between these two boulder clays.

The marine March Gravels of the Fenland have been described as resting on a chalky boulder clay[4], and it is obviously not possible that the chalky boulder clay at Peterborough, for example, was laid down by ice crossing the oolitic rocks from the north-west. The chalky boulder clay of Fenland contains Cretaceous material from Lincolnshire, local Jurassic septaria, felspathic grit, and schists and gneisses which could be derived from Cromer Till, in a matrix of local Jurassic clays. This assemblage, especially in southern and western Fenland, points to ice-movement from the north across the Lincolnshire Wolds. This direction is parallel to that of the Upper Chalky of West Suffolk, and the Fenland boulder clay is most easily accounted for as having been brought by the Upper Chalky Ice. It should be emphasized that it is different in many ways from the Hessle Boulder Clay of the Fens, which in any case overlies the March Gravels.

If this explanation of the chalky boulder clays is correct, correlation becomes possible between East Anglia and a large area of the East Midlands. Deeley[7], Boswell[1] and Hollingworth[8] have shown that the early Pennine Boulder Clay of the East Midlands underlies later chalky boulder clay from the north-east, and many of the relevant memoirs of the Geological Survey admit a similar sequence. The simplest explanation of these facts is that the older Pennine Ice from Derbyshire to the Fens was the same as that which deposited the Lower Chalky Boulder Clay of East Anglia: and that the younger ice which brought Cretaceous and other material from the north-east to the districts round the Trent, the Stratford Avon and the neighbourhood of Buckingham, was contemporaneous with that which deposited the Upper Chalky Boulder Clay of Suffolk. This hypothesis fits the facts better than Harmer's conception of a single ice-sheet with its fanning-out and cross-currents.

It is hoped to publish the full evidence on which this work is based as soon as possible. The boulder clay samples are still being worked out in detail. I would like to thank Dr. W. J. Arkell for identifying many of the Jurassic fossils.

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[2] Solomon, J., *Proc. Geol. Assoc.*, **43**, 244 (1932).
[3] Baden-Powell, D. F. W., and Moir, J. R., *Geol. Mag.*, **79**, 210 (1942).
[4] Paterson, T. T., and Fagg, B. E. B., *Proc. Prehist. Soc.*, **6**, 4 (1940).
[5] Harmer, F. W., *Proc. Yorks. Geol. Soc.*, **21**, 88 (1928).
[6] Baden-Powell, D. F. W., *Geol. Mag.*, **71**, 215 (1934).
[7] Deeley, R. M., *Quart. J. Geol. Soc.*, **42**, 439 (1886).
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AMALGAMATION OF SOME ALLOYS OF GOLD, SILVER AND COPPER

By Dr. DOUGLAS RENNIE HUDSON
University of Leeds

THE surface of amalgamated metals is greasy to touch, and lustrous in appearance like liquid mercury. In a previous publication[1] the extreme tenuity ($2{\cdot}7 \times 10^{-4}$ cm.) of the film necessary to confer these properties on a pure silver surface was noted. This observation has been confirmed for gold-rich alloys of the legalized carat compositions used for jewellery, for some silver alloys, and for bronzes. By the nature of the problem, exactly reproducible

results could scarcely be expected, but, in fact, surprisingly concordant values have been obtained. The problem is of interest in the amalgamation of coarse gold concentrates from the corduroy table on the Rand[2].

Gold-rich alloys. Values of the equivalent film thickness in the hard-rolled state are too erratic to be compared, since in this condition the alloys crumble on mere contact with liquid mercury. This is the phenomenon of 'season cracking' attributed to intercrystalline penetration of the strained metal by liquid mercury.

In the rolled state (half-hard, with 'close' surface texture), the equivalent thickness of mercury is a little more than 1×10^{-4} cm. On fully annealing the gold alloys in hydrogen, giving a surface with 'open' texture, this thickness rises somewhat, attaining a value less than 2×10^{-4} cm.

After polishing the half-hard alloys to a 000 emery finish, the equivalent thickness is reduced to about a third. In annealed alloys similarly polished the equivalent thickness is very slightly less. The polishing appears to activate the surface and renders it very able to take up the mercury; a similar procedure may be adopted to bring annealed metals into a state of standard strain for electrode potential determinations.

Comparison tests on a few commercial golds showed a wide variation in the thickness of the equivalent layer, namely, $0{\cdot}45$–$2{\cdot}7 \times 10^{-4}$ cm. This is attributed to wide differences in the surface texture, polish, roughness and hardness. (A smooth surface may have an 'open' texture[3].) In all cases burnished surfaces yielded thin films. 18-ct. 'white gold' was particularly difficult to amalgamate. 'Rolled' gold gave the low value of $0{\cdot}22 \times 10^{-4}$.

Silver alloys. In silver alloys the effect of surface roughness is shown by the equivalent thickness of more than 3×10^{-4} cm. on the plated pure silver surface of a new shilling, compared with $2{\cdot}7 \times 10^{-4}$ cm. for pure silver and $0{\cdot}6 \times 10^{-4}$ cm. for the underlying basis metal containing only 50 per cent silver, when polished to a 000 emery finish. A similarly prepared surface on sterling silver (92·5 per cent) gave $0{\cdot}6 \times 10^{-4}$ cm.

On standing for a few hours, the lustrous surface becomes mat. This is not due, as might be suggested, to diffusion of mercury atoms into the silver crystals, and subsequent fixation as a result of synthesis[4] of Ag_2Hg_4. This process is much slower, and may take weeks, whereas the lustre of the mat surface can be restored by gentle rubbing. Probably it is due to thixotropic setting within the surface layer of mercury[5].

Copper alloys. Most gold and silver alloys amalgamate readily on mere contact with mercury, and the wetted area extends quickly on gentle rubbing. But copper and its alloys are difficult to amalgamate by contact, even when surface cleanliness is not in question. Prolonged rubbing is necessary, and it is not surprising that resulting films are much thicker, as much as 14×10^{-4} cm. having been observed. However, they do not seem to differ in behaviour from amalgamated alloys of gold and silver. This difficulty in wetting is quite consistent with immediate formation in air of a thin invisible oxide film on newly polished copper surfaces, which has been deduced from electron diffraction and surface reflectivity measurements. Chemical amalgamation yields much thinner films; about $1{\cdot}4 \times 10^{-4}$ cm. by displacement in mercurous nitrate solution, and about half that thickness in a mixture of mercury and nitric acid. This also is consistent with the shielding effect of an oxide layer.

Phosphor bronze, and copper alloyed with a little beryllium (so-called *beryllium bronze*) closely resembling it in physical properties, both gave surprisingly low thickness for contact amalgamation of surfaces polished to a 000 emery finish, respectively $0{\cdot}07$ and $0{\cdot}1 \times 10^{-4}$ cm. Values obtained by chemical amalgamation, while still small at $0{\cdot}12$–$0{\cdot}19 \times 10^{-4}$ cm. and $0{\cdot}35$–$1{\cdot}6 \times 10^{-4}$ cm., much exceeded the contact values. It is clear that surface conditions are very important in the amalgamation of copper alloys.

Grateful acknowledgment is made to the Carnegie Trust, which supplied the precious metals, and particularly to its secretary, Dr. Peddie.

[1] Hudson, D. R., *Metallurgia*, **29**, 299 (1944).
[2] Year Book of the Union of South Africa (1940).
[3] Rayleigh, Lord, *Proc. Roy. Soc.*, A, **144**, 266 (1934).
[4] Hudson, D. R., *J. Phys. Chem.*, **49**, 483 (1945).
[5] Hudson, D. R., *Nature*, **153**, 562 (1944).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, February 23

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Discussion on "Corrosion in Electrical Apparatus" (to be opened by Brigadier F. H. Maclennan).

INSTITUTION OF THE RUBBER INDUSTRY, MANCHESTER SECTION (at the Engineers' Club, Albert Square, Manchester), at 6.15 p.m.—Mr. L. A. Oliver: "Machinery and Layout in German Rubber Plants".

Tuesday, February 24

UNIVERSITY COLLEGE LONDON (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Prof. Daryll Forde: "Anthropological Analysis of Social Change".*

ILLUMINATING ENGINEERING SOCIETY (at the Lighting Service Bureau, 2 Savoy Hill, London, W.C.2), at 6 p.m.—Discussion "That Artificial Lighting is an Adequate Substitute for Natural Lighting".

SOCIETY OF INSTRUMENT TECHNOLOGY (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 6.30 p.m.—Dr. H. W. Thompson, F.R.S.: "Infra-Red Methods of Analysis and Control".

TEXTILE INSTITUTE (joint meeting with the MANCHESTER GEOGRAPHICAL SOCIETY, in the Geographical Hall, St. Mary's Parsonage, Manchester), at 6.30 p.m.—Mr. F. Shuttleworth: "Some Strange Native Customs and Ways of Using Textile Materials".

CHEMICAL SOCIETY, SOCIETY OF CHEMICAL INDUSTRY, and ROYAL INSTITUTE OF CHEMISTRY, EDINBURGH AND EAST OF SCOTLAND SECTIONS (joint meeting with the EDINBURGH UNIVERSITY CHEMICAL SOCIETY, in the Biochemistry Lecture Theatre, Teviot Place, Edinburgh), at 7 p.m.—Prof. W. F. K. Wynne Jones: "Proton Transfer and Analogous Reactions".

INSTITUTION OF ELECTRICAL ENGINEERS, LONDON STUDENTS' SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 7 p.m.—Mr. P. Good: "The General Aspects of Standardization" (Presidential Address).

SOCIETY OF DYERS AND COLOURISTS, SCOTTISH SECTION (at St. Enoch Hotel, Glasgow), at 7 p.m.—Mr. E. Marney: "All-over Pigment Coloration of Textiles".

ROYAL INSTITUTE OF CHEMISTRY, LONDON AND SOUTH-EASTERN COUNTIES SECTION (at the Cherry Tree, Welwyn Garden City), at 8 p.m.—Prof. D. H. Hey: "Reactions of Benzoyl Peroxide".

Wednesday, February 25

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Mr. C. Butement: "Three-Dimensional Photography".

ROYAL MICROSCOPICAL SOCIETY, SECTION OF INDUSTRIAL MICROSCOPY (in the Hastings Hall, B.M.A. House, Tavistock Square, London, W.C.1), at 5.30 p.m.—Miss M. Dempsey: "The Structure of the Skin and Leather Manufacture".

SOCIETY FOR VISITING SCIENTISTS (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion on "The Growing Points in Science", 2. (To be opened by Prof. A. A. Hall and Prof. C. H. Waddington, F.R.S.)

Thursday, February 26

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Sir Wallace Akers: "The Research Laboratories of the Imperial Chemical Industries, Ltd.".

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Exhibition Meeting (Exhibits of botanical and zoological interest, with brief comments by the Exhibitors).

ROYAL AERONAUTICAL SOCIETY (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 6 p.m.—Prof. R. L. Lockley: "The Evolution of the Design of an Aeroplane".

ROYAL STATISTICAL SOCIETY, SHEFFIELD GROUP OF THE INDUSTRIAL APPLICATIONS SECTION (at the Royal Victoria Hotel, Sheffield), at 6.30 p.m.—Miss B. Pickersgill: "Graphical Methods for the Demonstration of Simple Statistical Relations".

ROYAL INSTITUTE OF CHEMISTRY, MANCHESTER AND DISTRICT SECTION (at the Engineers' Club, Albert Square, Manchester), at 7 p.m.—Mr. J. H. Carrington: "Rubber".

ROYAL PHOTOGRAPHIC SOCIETY, SCIENTIFIC AND TECHNICAL GROUP (at 16 Prince's Gate, London, S.W.7), at 7 p.m.—Annual General Meeting, followed by a Film Show.

SOCIETY OF DYERS AND COLOURISTS, WEST RIDING SECTION (at the Great Northern Victoria Hotel, Bradford), at 7.15 p.m.—Dr. A. H. Gordon: "The Composition of Wool".

Friday, February 27

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Geophysical Discussion on "Recent Work on the Earth's Main Magnetic Field". (Fellows of the Geological Society are invited to attend.)

INSTITUTION OF MECHANICAL ENGINEERS (at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Discussion on "The Future of Fuel and Power" (to be opened by Dr. F. Rogers).

BRITISH INSTITUTION OF RADIO ENGINEERS, MIDLAND SECTION (at the Technical College, The Butts, Coventry), at 6.30 p.m.—Mr. G. F. N. Knewstub: "The Design of Electronic Calculating Machines".

INSTITUTION OF ELECTRICAL ENGINEERS (at the Central Hall, Westminster, London, S.W.1), at 6.30 p.m.—Dr. P. Dunsheath: "Electricity and Everyman" (Faraday Lecture).*

BRITISH GLACIOLOGICAL SOCIETY (at the Electrical Laboratory, Oxford), at 8.15 p.m.—Mr. Gerald Seligman: "Some Aspects of Snow and Glaciers".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. Linus C. Pauling: "The Nature of Forces between Large Molecules of Biological Interest".

UNIVERSITIES FEDERATION FOR ANIMAL WELFARE, CAMBRIDGE UNIVERSITY BRANCH (at St. John's College, Cambridge).—Symposium on "Pain" (to be opened by Prof. E. D. Adrian, O.M., F.R.S., and Sir Frederic Bartlett, F.R.S.).*

Saturday, February 28

LONDON COUNTY COUNCIL (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Dr. Redcliffe N. Salaman, F.R.S.: "The Potato Came to Europe".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

PLANT PATHOLOGIST to investigate an unexplained disease of coconuts, in Jamaica—The Under-Secretary of State, Colonial Office (Research Department), Palace Chambers, Bridge Street, London, S.W.1 (February 28).

LABORATORY STEWARD at the College, Swindon—The Borough Education Officer, Civic Offices, Swindon (February 28).

CHEMISTS (men and women), SCIENTIFIC OFFICER CLASS and EXPERIMENTAL OFFICER CLASS, in the Chemical Inspection Department of the Ministry of Supply—The Ministry of Labour and National Service, Technical and Scientific Register, Room 669, York House, Kingsway, London, W.C.2, quoting F78/48A (February 28).

GEORGE WILLIAM BRITT STUDENTSHIP IN PHYSICS, and the ARTHUR JUBBER STUDENTSHIP for advanced study or research in any subject, preferably in the field of Chemistry, Botany, Mathematics, Ancient, Modern or Natural History—The Academic Registrar, University of London, Senate House, London, W.C.1 (March 1).

GRADUATE ASSISTANT (with zoology degree and good field knowledge of birds)—The Director, Edward Grey Institute, 91 Banbury Road, Oxford (March 5).

SENIOR ASSISTANT IN THE ELECTRICAL ENGINEERING DEPARTMENT—The Principal, Northampton Polytechnic, St. John Street, London, E.C.1 (March 6).

PRINCIPAL SCIENTIFIC OFFICER at the Post Office Engineering Research Station, Dollis Hill, London, N.W.2, to advise and undertake research work on physiological problems—The Director General, Personnel Department (C.C.B.), Headquarters Building, General Post Office, London, E.C.1 (March 8).

SCIENCE MASTER at Longerenong Agricultural College under the Victoria Department of Agriculture—The Secretary, Universities Bureau of the British Empire, 8 Park Street, London, W.1 (March 8).

GEOLOGISTS (about 10) and SENIOR GEOLOGISTS (1 or 2) at the Geological Survey and Museum—The Secretary, Civil Service Commission, Scientific Branch, 27 Grosvenor Square, London, W.1, quoting No. 2117 (March 15).

PROFESSOR OF PSYCHIATRY—The Registrar, The University, Leeds 2 (March 22).

SENIOR LECTURER and LECTURER (2) IN PHYSIOLOGY—The Secretary of University Court, The University, Glasgow (March 31).

PRINCIPAL SCIENTIFIC OFFICER for work on the Commonwealth Potato Collection, Cambridge—The Secretary, Commonwealth Agricultural Bureaux, 2 Queen Anne's Gate Buildings, London, S.W.1 (April 1).

ASSISTANT IN ASTRONOMY—The Director, University of London Observatory, Mill Hill Park, London, N.W.7 (April 1).

RAMSAY MEMORIAL FELLOWSHIPS FOR CHEMICAL RESEARCH—The Joint Honorary Secretaries, Ramsay Memorial Fellowships Trust, University College London, Gower Street, London, W.C.1 (April 17).

PRINCIPAL METEOROLOGIST, a SENIOR METEOROLOGIST, a METEOROLOGIST and a JUNIOR METEOROLOGIST; a PRINCIPAL TECHNICAL ASSISTANT, a SENIOR TECHNICAL ASSISTANT, and a TECHNICAL ASSISTANT (Grade I), in the Meteorological Services, Department of Transport, under the Government of the Union of South Africa—The Secretary, Office of the High Commissioner for the Union of South Africa, Trafalgar Square, London, W.C.2 (April 30).

CHAIR OF PHARMACOLOGY—The Registrar, The University, Sydney, N.S.W., Australia (June 30).

LECTURER IN THE CHEMISTRY DEPARTMENT—The Secretary, King's College of Household and Social Science, Campden Hill Road, London, W.8.

LABORATORY ASSISTANT (girl or woman)—The Principal, Furzedown Training College, Welham Road, London, S.W.17.

LABORATORY ASSISTANT (woman) at Dalston County Secondary School, Shacklewell Lane, London, E.8—The Education Officer (Estab./2), County Hall, London, S.E.1.

LABORATORY STEWARD (Grade C)—The House Governor and Secretary, Gordon Hospital, Vauxhall Bridge Road, London, S.W.1.

ORGANIZING SECRETARY of the proposed Institute of Education—The Registrar, University College, Leicester.

SCIENCE GRADUATE (Senior Scientific Officer grade) with an interest in economics and statistics to carry out operational research in the iron and steel industry—The Personnel Officer, British Iron and Steel Research Association, 11 Park Street, London, W.1.

DEMONSTRATOR for the DEPARTMENT OF AERODYNAMICS—The Registrar, College of Aeronautics, Cranfield, Bletchley, Bucks.

ASSISTANT TECHNICAL LIBRARIAN—The Secretary, British Internal Combustion Engine Research Association, 111–112 Buckingham Avenue, Slough, Bucks.

ELECTROLOGICAL TECHNICIAN (Grade B) IN THE DEPARTMENT OF ANATOMY—The Secretary, St. Mary's Hospital Medical School, Paddington, London, W.2.

GOVERNMENT CHEMIST in Mauritius—The Director of Recruitment, Colonial Service, 15 Victoria Street, London, S.W.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Transactions of the Royal Society of Edinburgh. Vol. 61, Part 2, No. 18: The Geology of the Highland Border—Stonehaven to Arran. By Dr. J. G. C. Anderson. Pp. 479–516 + 1 plate. (Edinburgh and London: Oliver and Boyd, 1947.) 12s. [225

Chelsea Polytechnic. 51st Annual Report, Session 1945–46. Pp. 18. (London: Chelsea Polytechnic, 1947.) [225

Board of Trade. Working Party Reports—Linoleum and Felt Base. Pp. viii + 50 + 2 plates. (London: H.M. Stationery Office, 1947.) 1s. 6d. net. [225

Ministry of Education. Education for Management: Management Subjects in Technical and Commercial Colleges. Report of a Special Committee appointed by the Minister of Education. Pp. 32. (London: H.M. Stationery Office, 1947.) 6d. net. [225

Department of Scientific and Industrial Research. Report of the Water Pollution Research Board, with the Report of the Director of Water Pollution Research, 1st July 1939 to 31st December 1945. Pp. iv + 78. (London: H.M. Stationery Office, 1947.) 1s. 3d. net. [225

Report of the Rugby School Natural History Society for the Year 1946. (80th Issue.) Pp. 82. (Rugby: George Over, Ltd., 1947.) [225

Survey of Sickness, October 1943 to December 1945. By Patrick Slater. A Report on a Series of Surveys on the State of Health of the Civilian Population between these dates, made for the Ministry of Health. Pp. 76. (London: Social Survey, 1946.) Not for sale. [225

Other Countries

What is Missing. By Dr. B. A. Sokolow. (Kosmopolit-Akademie, Postumae N.1.) Pp. 32. (Helsinki: Mrs. M. Roneveal, Box 134, n.d.) [125

American Institute of Crop Ecology. International Agro-Climatological Series. Study No. 1: Ecological Crop Geography of the Ukraine and the Ukrainian Agro-Climatological Analogues in North America. By M. Y. Nuttonson. Pp. 24. Study No. 2: Agricultural Climatology of Poland and its Agro-Climatic Analogues in North America. By M. Y. Nuttonson. Pp. 12. Study No. 3: Agricultural Climatology of Czechoslovakia and its Agro-Climatic Analogues in North America. By M. Y. Nuttonson. Pp. 12. (Washington, D.C.: American Institute of Crop Ecology, 1947.) [125

International Astronomical Union. 43rd Name-List of Variable Stars. Pp. 78. (Moscow: Academy of Sciences of the U.S.S.R., 1947.) [125

American Philosophical Society. Year Book 1946, January 1, 1946–December 31, 1946. Pp. 459. (Philadelphia: American Philosophical Society, 1947.) [155

Nigeria. Annual Report on the Forest Administration of Nigeria for the Year 1945–46. Pp. 44. (Lagos: Government Printer; London: Crown Agents for the Colonies, 1947.) 9d. [155

RCA Technical Papers (1919–1945). Index, Vol. 1. Pp. vi + 143. RCA Technical Papers (1946). Index, Vol. 2a. Pp. vi + 21. (Princeton, N.J.: Radio Corporation of America, 1947.) Free. [155

South African Council for Scientific and Industrial Research. First Annual Report, 1945–46. Pp. 27. (Pretoria: South African Council for Scientific and Industrial Research, 1947.) [155

Bulletin of the Bingham Oceanographic Collection. Vol. 8, Art. 1: A Review of the Types of Polychaetous Annelids at the Peabody Museum of Natural History, Yale University. By Olga Hartman. Pp. 98. (New Haven, Conn.: Peabody Museum of Natural History, 1942.) 1.50 dollars. [225

Indian Forest Records. Vol. 6, No. 2: The Stomates and Early Growth of some Timber Trees of the Malabar Coast. By Dr. A. L. Griffith. Pp. 62–92 + 21 plates. (Delhi: Manager of Publications, 1946.) 2.12 rupees; 4s. 9d. [225